

Energy Supply

Solar and Renewable Resources Technologies

Executive Budget Summary

Mission

The Energy Efficiency and Renewable Energy (EERE) program supports the Department of Energy's strategic objectives of increasing the efficiency and productivity of energy use, while limiting environmental impacts; reducing the vulnerability of the U.S. economy to disruptions in energy supplies; ensuring that a competitive electricity generation industry is in place that can deliver adequate and affordable supplies with reduced environmental impact; supporting U.S. energy, environmental, and economic interests in global markets; and delivering leading-edge technologies that are critical to the DOE mission and the nation. EERE activities funded under the Energy and Water Development Appropriation are designed to advance a broad range of renewable electric, fuel, and related storage and power delivery technologies to provide the nation with a more reliable, affordable and clean energy supply.

EERE's programs work in cost-shared partnerships with the nation's manufacturers, utilities, states, and the public to advance the development and facilitate the deployment of renewable energy technologies. By accelerating the use of renewable energy, EERE's programs help to strengthen the economy, improve the environment, and ensure a more secure future.

Strategy

The EERE strategic goals reflect the Administration's emphasis on Federal energy R&D for delivering significant benefits to the nation. In its 1997 review of the national energy R&D portfolio, the President's Committee of Advisors on Science and Technology recommended increases in a number of renewable energy R&D programs. The Committee noted that renewable technologies produce near-term and rapidly expanding public benefits, including air emissions reductions, reduced dependence on imported oil, and lower costs to households and firms. The Committee called for significant expansion of renewable energy programs in order to meet the energy challenges and opportunities of the 21st century.

EERE plays a leading role in implementing several Administration priorities. The President's Million Solar Roofs Initiative, implemented by the EERE Office of Utility Technologies, is aimed at facilitating the installation of photovoltaic and solar hot water systems on one million buildings across the nation by 2010.

Under a Distributed Generation initiative, EERE is coordinating program efforts that advance small-scale, on-site power generation as an alternative to centralized baseload power generation. Technologies for distributed generation, including photovoltaics, concentrating solar power, fuel cells, gas turbines, hydrogen production and storage, and hybrid fossil/renewable power systems, can greatly reduce both energy use and carbon emissions. As part of these efforts, EERE has launched the Combined Heat and

Power initiative to develop and deploy systems that produce both electricity and thermal energy from a single power source. Recent studies indicate that widespread use of combined heat and power could sufficiently reduce greenhouse gas emissions. Also under the Distributed Generation initiative, demonstrations of residential and building-sized hydrogen/natural gas fuel cells for off-grid applications are underway.

A transmission reliability program, launched in FY 1999, seeks to ensure an efficient, reliable power delivery system in the U.S. during the electricity industry's transition to competitive markets. This program will develop advanced technologies that will enable the lowest cost efficient power delivery systems with integration of distributed generation resources. These technologies will likely include real time controls for reliable, efficient operation of our Nation's power system under both normal and emergency conditions.

An electricity restructuring initiative, also launched in FY 1999, seeks to provide unbiased technical assessments to Federal and State officials on restructuring issues related to energy efficiency and renewable energy. These assessments assist decision makers to develop and coordinate utility restructuring legislation and regulations that include suitable policy and market mechanisms for renewable energy and energy efficiency.

During the 20th century, our nation's economy has depended heavily on imported fossil fuels. Biomass — a renewable alternative — represents a tremendous, largely untapped, domestic resource for our energy future. By investing in a bioenergy industry today, we can cultivate and harness these renewable resources to fuel our cars, power our homes and industries, and supply our chemical needs in the 21st century. The Department of Energy, along with other federal agencies and private partners, is launching a national partnership to develop an integrated industry to produce power, fuels, and chemicals from crops, trees, and wastes. By making a "ton of biomass" a viable market competitor to a barrel of oil or a railroad car of coal, this initiative will help grow the U.S. economy, strengthen U.S. energy security, protect the environment, and revitalize rural America. This effort will integrate the efforts from existing DOE R&D in biomass power, transportation biofuels and the forest products and agriculture Industries of the Future to enable technologies that produce different combinations of power, fuels, chemicals and other products from different feedstocks in different areas of the country. It is only through the integration of these efforts that biomass will be an effective competitor to imported fossil fuels.

Program Drivers - EERE's programs target Federal resources in key areas that provide critical national benefits; stimulate complementary private investments; leverage market forces; and respond to five significant drivers:

- # National Security;
- # Economic Competitiveness;
- # Environmental Quality;
- # Climate Change; and,
- # Electricity Restructuring.

- # **National Security** - During the past 25 years, three major disruptions in the world oil market have shaken the global economy. In 1997, U.S. net oil imports accounted for approximately 49 percent of domestic petroleum consumption. By 2020, U.S. net oil imports are expected to grow

to over 70 percent of domestic petroleum consumption, with Persian Gulf nations accounting for over 64 percent of the world's oil exports. In 2020, U.S. net annual expenditures for imported crude oil and products are projected to exceed \$180 billion in current dollars. Given historical precedents and future oil market trends, the United States has a critical interest in diminishing the nation's reliance on foreign oil through the use of indigenous renewable energy sources. EERE's efforts to implement a smart energy policy recognize this security concern and work to reduce U.S. dependence on foreign oil. As a related benefit, EERE's work on renewable energy reduces the U.S. trade deficit by reducing costly energy imports.

- # **Economic Competitiveness** - In addition to reducing the nation's vulnerability to disruptions in energy supplies, EERE's research and development efforts advance U.S. economic interests. Carried out in partnership with industry, national laboratories, and universities, EERE's research and development programs are designed to maintain America's technological expertise and competitive advantage in the global market. A smart energy policy, as promoted by EERE's programs, strengthens the nation's economic power. EERE's investments not only lay the foundation for a more sustainable energy future but also open markets for U.S. manufacturers of advanced renewable energy technologies and related power technologies.

EERE also sponsors international programs to promote U.S. renewable energy technologies and services in international markets, to help ensure that U.S. companies are competitive in the large and growing global marketplace. The World Bank has estimated that, over the next four decades, developing countries alone will require five million megawatts of new electrical capacity to meet the needs of their citizens and their expanding economies. (The world's total installed capacity today is three million megawatts.) This demand represents a tremendous potential for job creation and technology sales, even if renewable technologies only capture a fraction of the worldwide market.

- # **Environmental Quality** - Air pollution, particularly in urban centers, ranks high among the nation's most pressing environmental concerns. In advancing a smart energy policy, EERE programs work to mitigate and minimize the environmental costs associated with energy use. Renewable technologies advanced by EERE offer a cleaner, environmentally responsible option for generating power.

- # **Climate Change** - The President's FY 2000 budget request for EERE programs is a major element of his proposal to invest \$6.3 billion over five years to reduce greenhouse gas emissions to below 1990 levels by 2008 - 2012 through energy technology research and development and tax incentives. In 1997, a major study conducted by five national laboratories documented the critical role that development and deployment of renewable energy technologies can play in reducing greenhouse gases. Given the cost savings associated with these technologies, the study noted that aggressive investment in energy R&D and deployment could lead to significant emissions reductions without raising the nation's energy bill.

- # **Electricity Restructuring** - EERE is working with utilities, industry, states, and consumers to ensure that electricity restructuring results in a competitive and effective electric power industry. Power market restructuring presents an opportunity to reduce energy costs, advance the use of energy efficient and renewable energy technologies, and provide affordable services with reduced environmental impacts.

Major Changes

Managing for Results - Since the beginning of FY 1998, the Department has put in place a new management team for the Office of Energy Efficiency and Renewable Energy (EERE). This new team has been resolving long-standing management issues and is committed to making further improvements. Specific reforms that have been accomplished in the past year as well as new initiatives are summarized below:

- # **Strategic Planning for Results and Technology Roadmaps** - Consistent with the Government Performance and Results Act, EERE is developing a new strategic plan with a focus on results. This plan builds on the technology roadmaps that the Department and the Office are developing. In addition, it will sharpen the Office's focus on procurement and business strategies that will improve the efficiency and effectiveness of operations.
- # **Increasing Competition and Refining Merit Review Processes** - EERE is increasing the amount of its program funds that are awarded on a competitive basis, and this approach is expected to improve the quality of the resulting work products. In 1998, the Department competed the roughly \$1 billion management and operating contract for the National Renewable Energy Laboratory, and the resulting contract strengthens the laboratory's management team and sharpens its mission focus.

During the past year, EERE also has issued a broad-based solicitation for proposals on information dissemination and outreach activities. This solicitation involves competitive applications for approximately \$13,500,000 million in work activities, much of which had been awarded on a non-competitive basis in the past. In 1998, the Office also issued a broad-based solicitation for research, development, and demonstration (RD&D) proposals and issued various targeted solicitations for proposals in specific technology areas.

In 1998, EERE also has refined its objective merit review processes through new regulations and additional guidance and training. These reviews of proposals by independent experts are expected to assure the selection of the highest quality projects.

- # **Managing Smarter** - EERE has made notable progress in reducing uncosted obligations. Since the beginning of FY 1996, we have reduced the uncosted balances in the Solar and Renewable Resources Technologies by nearly 62 percent, from a beginning balance FY 1996 of nearly \$268,000,000 to an ending FY 1998 balance of approximately \$102,000,000. While this represents substantial progress in addressing this Congressional concern, EERE has taken steps toward further reducing uncosted balances. We are working to accelerate the obligation and costing of funds and we are also examining other steps that can reduce these balances without compromising sound management practices. In addition, just like any good business, EERE has

focused on assuring that its workforce for the 21st Century includes adequate staff with necessary skills to manage long-term projects supported by recent budget increases.

- # **Strengthening Program Integration** - Since the solutions to our energy efficiency and renewable energy challenges cross sector lines, EERE is focusing increased attention on stimulating increased integration across technologies and across their applications. Two leading efforts are the Bioenergy Initiative and the EnergySmart Schools Initiative.
- # **Leveraging Federal Investments by Expanding Partnerships with Federal, State and Other Entities** - EERE is strengthening its partnerships with other government entities and the private sector to better leverage the Federal investment in RD&D and to facilitate the deployment of new technologies. These partnerships involve other components of the Department of Energy (the Offices of Fossil Energy, Nuclear Energy, and Science) and other Federal agencies. EERE also has begun an initiative with the States to establish a much closer working relationship with State organizations pursuing energy technology RD&D. EERE also works closely with national laboratories, businesses, universities, non-profit organizations, and the Congress to: set research and development priorities; conduct high-priority research; facilitate the deployment of technologies by the private sector, and disseminate information. In many cases, EERE activities are jointly funded with private sector or other public sector entities. EERE is also strengthening the role of its Regional Support Offices in delivering services at the state and local level.
- # **Increasing Emphasis on Project Management** - In 1999, EERE will place an increased emphasis on strengthening systems necessary to manage effectively the cost, schedule, and performance of projects. This emphasis is increasingly important as the Offices intensifies its role in demonstration projects.
- # **Emphasizing Program Evaluation and Continuous Improvement** - EERE is committed to following best business practices, which involve effective performance measurement and refinement of program strategies as new information is obtained. EERE has discontinued activities that have not met pre-determined goals and will continue to modify its strategies based on its program analysis and evaluation results.

FY 2000 Congressional Budget Request

In support of its priorities, EERE submits the following FY 2000 budget request. The table covers both the Energy and Water Development and Interior and Related Agencies Appropriations. A more detailed table for the Solar and Renewable Resources Technologies follows.

Office of Energy Efficiency and Renewable Energy

FY 2000 Congressional Budget Request

(in thousands of dollars)				
	FY 1998	FY 1999	FY 2000	\$ Change
Solar and Renewable Resources Technologies.	294,351	336,000	398,921	62,921
Building Technology, State and Community Programs.	232,702	262,221	335,881	73,660
Federal Energy Management Program.	19,800	23,818	31,868	8,050
Industrial Technologies.	133,911	165,859	171,000	5,141
Transportation Technologies.	189,972	202,071	252,100	50,029
Policy and Management.	28,925	37,732	46,666	8,934
Total Program Funding.	899,661	1,027,701	1,236,436	208,735
PODRA and Prior Year Balances.	-45,403	-64,000	-25,821	38,179
Total Budget Authority ^a	854,258	963,701	1,210,615	246,914

^aTotal Budget Authority figures take into account prior year balances and projected receipts associated with the Petroleum Overcharge Distribution and Restitution Act (PODRA).

Solar and Renewable Resources Technologies

Program Mission

The mission of the Solar and Renewable Resources Technologies program is to lead the national effort to develop renewable energy technologies and to accelerate their acceptance and use, nationally and internationally. Within the Office of Energy Efficiency and Renewable Energy (EERE), the program supports research and development of clean, reliable renewable energy technologies and cutting edge power delivery technologies that will improve the performance and efficiency of electric power systems.

The Solar and Renewable Resources Technologies program contributes to national energy security, enhances U.S. economic competitiveness, and reduces the environmental impacts of energy-related activities. The program provides additional clean-power options for a restructured electricity supply industry and clean liquid biofuels for the transportation sector. The EERE Office of Power Technologies implements most of program activities, while the EERE Office of Transportation Technologies administers the transportation biofuels program.

Program Goals and Objectives

To improve the Nation's overall economic, energy security, and environmental health through the development of clean, competitive power technologies for the 21st century.

The principal strategy for the Solar and Renewable Resources Technologies program is to invest in renewable energy technologies research and development focused on core technology needs. This research and development provides the technological advances needed to develop competitive new energy systems and create the basis for industry investment in product development. Areas addressed include materials and component improvement, conversion efficiency, system integration, system control, and evaluation of component lifetime. While such fundamental research is necessary, it must be complemented with evaluation of system performance under real world conditions. Experience has shown that user acceptance and industry commercialization investment requires confidence in the day-to-day performance, operating cost, system reliability, and operating lifetime of renewable energy and power delivery technologies. The program's activities thus include prototype evaluation and system field tests where appropriate, to establish a basis for predicting operation and maintenance costs.

Since program success depends on industry's ultimate commercialization of the program's technologies under development, partnership with industry is essential. These partnerships include industry co-investment at increasing levels as technologies near the pre-commercialization stage.

Additionally, the program utilizes the talents found at the National Laboratories and within the state, university, and other research organizations across the U.S. in order to achieve its research and development objectives. This not only helps us to accomplish our R&D mission, but the States are also encouraged to share "lessons learned" through their own peer network activities. Similarly, we also partner with a number of universities across the country to conduct both fundamental and applied research. Whenever possible, we encourage our partners to provide viable prototype power technology

systems to schools and other educational facilities so that they may continue to receive the benefits of these clean power systems once our research work is done.

Specific program objectives include:

- # **To triple the installed U.S. electricity production capacity of non-hydropower renewable energy systems by 2010** – Increase capacity by 7,000 MW to 25,000 MW (base year is 1996) through advances in conversion technology and reductions in capital cost.
- # **To achieve sufficient advances in high temperature superconductivity by 2010** – Advances will result in commercial introduction by industry of at least two power system devices, such as superconducting motor, generator, transformer, transmission cable or fault current limiter.
- # **To achieve sufficient component and system integration improvements by 2010** – Improvements will result in commercial availability of energy storage systems for large scale power quality and solar or wind applications from at least three companies.
- # **To achieve sufficient levels of biofuel ethanol technology advancement** – Advancements will establish at least three commercial plants that use agricultural and/or municipal solid wastes by 2004, and will demonstrate an industrial ethanol site that uses energy crops by 2005.

Attainment of these objectives will contribute to Departmental strategic objectives as stated in the Department of Energy Strategic Plan of September 1997. These strategic objectives are to reduce the vulnerability of the U.S. economy to disruptions in energy supplies; to ensure adequate and affordable energy supplies in a competitive marketplace while importing environmental quality; to increase the efficiency and productivity of energy use; and to support U.S. energy and economic competitiveness in global markets.

The table below reflects projected aggregated benefits to the nation resulting from the Solar and Renewable Technologies program investments in technology advancements. Primary Energy Displaced refers to fossil fuels not consumed because electricity production from renewable energy sources will have displaced them or because energy has been saved through the use of advanced system technologies.

Metric	FY 2000	FY 2010	FY 2020
Primary Energy Displaced (Quads).	0.10	1.50	3.60
Energy Savings (\$ Billions).	0.20	1.40	5.80
Carbon Displaced Millions Metric Tons Carbon Equivalent (MMTCE)	3.00	30.00	64.00
Oil Displacement (Million of Barrels per Day).	0.00	0.17	0.48

As a comparison, estimated energy displaced in 2020 would be equal to today’s electricity consumption of the five-state region comprised of Indiana, Illinois, Ohio, Michigan, and Wisconsin.

Investments in research and development of renewable energy technology are essentially investments in renewable energy reserves -- in the same sense that significant oil or coal reserves add a measure of energy security for the nation. Technological advances often make renewable energy systems economically competitive, and while these renewable technologies may not immediately enter the

marketplace, they nevertheless become national assets. Unlike fossil fuel reserves, these renewable technology reserves will not be depleted.

Performance Measures

At the level of resources proposed in this budget request, significant progress is anticipated throughout the next five-year period. Demonstrative indicators of such progress in Renewable Energy and Power Delivery Technologies will be:

FY 2001- 2006 Performance Measures

Photovoltaic Energy Systems

- # Photovoltaic modules will be commercially available at approximately \$4 per watt in quantity orders, as opposed to \$5 per watt in 1997, a 20% decrease in cost.

Concentrating Solar Power Program

- # Dispatchable concentrating solar power systems will be capable of producing power at \$0.06 to \$0.08KWh.

Wind Energy Systems

- # Wind turbines capable of providing electricity at 2.5 cents per kilowatt-hour in good (15 mph) wind regions will be introduced commercially.

Biomass/Biofuels Energy Systems - Transportation

- # A three-fold improvement from 1998 levels of cellulase enzyme activity for converting cellulosic biomass to ethanol will be demonstrated, resulting in a 200% reduction in production costs.

Geothermal

- # Geothermal drill bits that provide double the life and double the penetration rate of today's drill bits will be commercially available. (Drilling typically accounts for 30% or more of geothermal project cost.)

Electric Energy Systems and Storage

- # **High Temperature Superconducting** - Testing will be in progress on a 5000 horsepower superconducting motor with half the losses of a comparable motor today. (In the United States, two-thirds of today's electricity is consumed by operating motors.)
- # **Energy Storage Systems** - Tests of an advanced battery storage systems requiring a projected 20% less square footage and with a 20% longer life than today's systems will be underway at a user site. (System space requirements are a critical factor in many customer evaluations, and system lifetime is a major factor in life cycle cost.)

Significant Accomplishments and Program Shifts

Photovoltaic Energy Systems

- # Achieved an increase in U.S. photovoltaic module production output of 14 megawatts in 1997, in comparison to 1996 output.

Concentrating Solar Power Program

- # Achieved 153 hours of continuous power generation at the Solar Two power tower, which uses molten salt as heat transfer energy source system.

Biomass/Biofuels Energy Systems - Biopower Systems

- # Completed operational testing of the Vermont indirect biomass gasifier and produced clean biogas.
- # Completed engineering design for Minnesota Gasification Project for a power plant for gasification of alfalfa stems.

Biomass/Biopower Energy Systems

- # **Transportation** - Established partnership with the timber industry, United States Forest Service, and local communities to evaluate environmental effects of forest watershed management when forest thinnings are created to suppress potential forest fires and used to produce ethanol, electricity, and bio-products.

Wind Energy Systems

- # Established the National Wind Technology Center as accepted site for collection of wind turbine certification data.

Geothermal

- # Attracted over 200 utilities to participate in the geothermal heat pump consortium.

Hydropower

- # Completed conceptual design for advanced “fish friendly” hydroturbine.

Electric Energy Systems and Storage

- # **Transmission Reliability** - Completed Technology Characterizations for all Office of Power Technologies programs, in cooperation with the Electric Power Research Institute (EPRI), and identified specific advancements needed for each technology to reach program goals.
- # **High Temperature Superconducting** - Achieved high temperature superconductor with current carrying capability of 1,000,000 amperes per square centimeter in laboratory tests, over 1,000 times more capacity than copper wire.
- # **Energy Storage Systems** - Completed assembly of storage program’s first transportable battery energy storage system (TBESS); installed TBESS at utility customer site for evaluation.

Funding Profile

(dollars in thousands)

	FY 1998 Current Appropriation	FY 1999 Original Appropriation	FY 1999 Adjustments	FY 1999 Current Appropriation	FY 2000 Request
Solar and Renewable Resources Technologies					
Solar Building Technology Research	2,625	2,900	700	3,600	5,500
Photovoltaic Energy Systems	64,691	66,800	5,400	72,200	93,309
Concentrating Solar Power	16,317	17,000	0	17,000	18,850
Biomass/Biofuels Energy Systems	58,116	72,750	450	73,200	92,391
Wind Energy Systems	32,128	33,200	1,571	34,771	45,600
Renewable Energy Production Incentive Program	2,954	4,000	0	4,000	1,500
Solar Program Support	0	0	0	0	10,000
International Solar Energy Program	1,375	3,750	2,600	6,350	6,000
National Renewable Energy Laboratory	3,200	2,000	1,900	3,900	1,100
Geothermal	28,694	28,500	0	28,500	29,500
Hydrogen Research.	15,806	21,000	1,250	22,250	28,000
Hydropower	729	2,000	1,250	3,250	7,000
Renewable Indian Energy Resources	3,939	3,500	1,279	4,779	0
Electric Energy Systems and Storage	43,262	39,500	600	40,100	41,000
Program Direction	15,651	17,100	1,000	18,100	19,171
Federal Building/Remote Power Initiative	4,864	4,000	0	4,000	0
Subtotal, Solar and Renewable Resources Technologies	294,351	318,000	18,000	336,000	398,921
Use of prior year balances	-24,447	-42,000 ^a	42,000 ^b	0	-821 ^c
Total, Solar and Renewable Resources Technologies	269,904	276,000	60,000	336,000	398,100

^aShare of EWD reduction for use of prior-year balances assigned to this program.

^bReflects spread of \$60,000,000 provided in the Omnibus Consolidated Appropriation Act.

^cReflects an appropriation transfer from the Geothermal Resources Development Fund.

Public Law Authorization:

P.L. 94-163, "Energy Policy and Conservation Act" (ECPA) (1975)
P.L. 94-385, "Energy Conservation and Product Act" (ECPA) (1976)
P.L. 95-91, "Department of Energy Organization Act" (1997)
P.L. 95-618, "Energy Tax Act of 1978"
P.L. 95-619, "National Energy Conservation Policy Act" (NECPA) (1978)
P.L. 95-620, "Powerplant and Industrial fuel Use Act of 1978"
P.L. 96-294, "Energy Security Act" (1980)
P.L. 100-12, "National Appliance Energy Conservation Act of 1987"
P.L. 100-615, "Federal Energy Management Improvement Act of 1988"
P.L. 101-218, "Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989"
P.L. 101-549, "Clean Air Act Amendments of 1990"
P.L. 101-575, "Solar, Wind, Waste, and Geothermal Power Production Incentives Act of 1990"

Climate Change Technology Initiative (CCTI) Departmental Crosscut

(dollars in thousands)

	FY 1998 Current Appropriation	FY 1999 Current Appropriation	FY 2000 Request	\$ Change	% Change
Energy & Water Development					
Energy Supply					
Solar and Renewable	269,904	336,000	398,921	62,921	18.7%
Nuclear Energy	0	0	5,000	5,000	100.0%
Subtotal, Energy Supply	269,904	336,000	403,921	67,921	20.2%
Science	0	13,500	33,000	19,500	144.4%
Total, Energy & Water	269,904	349,500	436,921	87,421	25.0%
Interior and Related Agencies					
Energy Conservation R&D	450,215	525,701	646,515	120,814	23.0%
Fossil Energy R&D	0	23,890	36,776	12,886	53.9%
Energy Information Administration	0	2,500	3,000	500	20.0%
Total, Interior and Related Agencies	450,215	552,091	686,291	134,200	24.3%
Total, DOE Climate Change Technology Initiative	720,119	901,591	1,123,212	221,621	24.6%

Program Funding Detail

(dollars in thousands)

	FY 1998 Current Appropriation	FY 1999 Current Appropriation	FY 2000 Request	Funding Change
Solar and Renewable Resources Technologies				
Solar Building Technology Research				
Space Conditioning and Water Heating	2,625	3,600	5,500	+1,900
Photovoltaic Energy Systems				
Fundamental Research	11,000	11,000	20,309	+9,309
Advanced Materials and Devices	24,000	27,000	27,000	0
Collector Research & Systems Development	29,691	34,200	46,000	+11,800
Total, Photovoltaic Energy Systems	64,691	72,200	93,309	+21,109
Concentrating Solar Power				
Distributed Power System Development	3,550	5,300	6,700	+1,400
Dispatchable Power System Development	6,850	5,970	5,340	-630
Advanced Component and System Research . . .	5,117	4,990	5,960	+970
Strategic Alliances & Market Awareness	800	740	850	+110
Total, Concentrating Solar Power	16,317	17,000	18,850	+1,850
Biomass/Biofuels Energy Systems				
Power Systems				
Thermochemical Conversion	1,500	1,550	2,700	+1,150
Systems Development	21,017	26,350	32,150	+5,800
ATS/Biomass for Cogeneration	2,564	0	0	0
Feedstock Development	1,723	2,300	3,100	+800
Regional Biomass Energy Program	985	1,250	1,000	-250
Total, Power Systems	27,789	31,450	38,950	+7,500
Transportation				
Ethanol Production	25,027	35,950	37,441	+1,491
Biodiesel Production	800	750	1,000	+250
Feedstock Production	2,500	2,800	5,500	+2,700
Regional Biomass Energy Program	2,000	2,250	3,500	+1,250
Integrated Bioenergy Research and Development	0	0	6,000	+6,000
Total, Transportation	30,327	41,750	53,441	+11,691
Total, Biomass/Biofuels Energy Systems	58,116	73,200	92,391	+19,191
Wind Energy Systems				
Applied Research	11,101	10,700	13,500	+2,800
Turbine Research	13,000	16,400	20,200	+3,800
Cooperative Research & Testing	8,027	7,671	11,900	+4,229
Total, Wind Energy Systems	32,128	34,771	45,600	+10,829
Renewable Energy Production Incentive Program	2,954	4,000	1,500	-2,500

(dollars in thousands)

	FY 1998 Current Appropriation	FY 1999 Current Appropriation	FY 2000 Request	Funding Change
Solar Program Support				
Electricity Restructuring	0	0	2,000	+2,000
Competitive Solicitation	0	0	8,000	+8,000
Total, Solar Program Support	0	0	10,000	+10,000
International Solar Energy Program	1,375	6,350	6,000	-350
National Renewable Energy Laboratory				
Facility Maintenance	1,000	3,900	1,100	-2,800
Construction	2,200	0	0	0
Total, National Renewable Energy Laboratory	3,200	3,900	1,100	-2,800
Geothermal				
Geothermal Electric R&D and Development	22,294	22,000	29,500	+7,500
Geothermal Heat Pump Deployment	6,400	6,500	0	-6,500
Total, Geothermal	28,694	28,500	29,500	+1,000
Hydrogen Research.	15,806	22,250	28,000	+5,750
Hydropower	729	3,250	7,000	+3,750
Renewable Indian Energy Resources	3,939	4,779	0	-4,779
Electric Energy Systems and Storage				
Transmission Reliability				
Power System Reliability	0	2,500	3,800	+1,300
Distributed Power	0	500	200	-300
Total, Transmission Reliability	0	3,000	4,000	+1,000
High Temperature Superconducting R&D				
Superconductivity Partnership Initiative	14,000	14,500	14,000	-500
Second Generation Wire Initiative	8,000	8,000	8,000	0
Strategic Research	9,579	10,000	9,000	-1,000
Total, High Temperature Superconducting R&D ..	31,579	32,500	31,000	-1,500
Energy Storage Systems				
Storage Systems Integration	1,950	2,200	3,000	+800
Key Components for Storage Systems	1,350	1,400	2,100	+700
Analysis and Utility Competition	539	900	900	0
Total, Energy Storage Systems	3,839	4,500	6,000	+1,500
Climate Challenge	0	100	0	-100
Electric & Magnetic Fields R&D	7,844	0	0	0
Total, Electric Energy Systems and Storage	43,262	40,100	41,000	+900
Program Direction				
Golden Field Office	1,509	1,700	2,645	+945
Idaho Operations Office	88	90	95	+5
Headquarters	14,054	16,310	16,431	+121
Total, Program Direction	15,651	18,100	19,171	+1,071

(dollars in thousands)

	FY 1998 Current Appropriation	FY 1999 Current Appropriation	FY 2000 Request	Funding Change
Federal Building/Remote Power Initiative	4,864	4,000	0	-4,000
Subtotal, Solar and Renewable Resources Technologies	294,351	336,000	398,921	+62,921
Use of prior year balances	-24,447	0	-821	-821
Total, Solar and Renewable Resources Technologies .	269,904	336,000	398,100	+62,100

Program Staffing

(whole FTEs)

	FY 1998	FY 1999	FY 2000	Change
Golden	18	15	15	0
Idaho	1	1	1	0
Headquarters	98	91	84	-7
Total, Solar and Renewable Resources Technologies .	117	107	100	-7

Funding by Site

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	\$ Change	% Change
Albuquerque Operations Office					
Albuquerque Operations Office	640	1,345	1,350	+5	0.4%
Atlanta Regional Support Office	272	805	1,205	+400	+49.7%
Boston Regional Support Office	1,330	1,650	1,875	+225	+13.6%
Chicago Regional Support Office	715	740	1,170	+430	+58.1%
Denver Regional Support Office	2,534	1,180	1,590	+410	+34.7%
Philadelphia Regional Support Office	2	203	203	0	0.0%
Seattle Regional Support Office	730	1,170	1,315	+145	+12.4%
Los Alamos National Laboratory	5,300	5,700	6,025	+325	+5.7%
Sandia National Laboratory	32,568	37,664	47,856	+10,192	+27.1%
National Renewable Energy Laboratory	95,954	116,973	126,624	+9,651	+8.3%
Golden Field Office	43,451	61,288	64,247	+2,959	+4.8%
Total, Albuquerque Operations Office	183,496	228,718	253,460	+24,742	+10.8%
Chicago Operations Office					
Chicago Operations Office	3,697	2,100	2,100	0	0.0%
Argonne National Laboratory	4,000	4,025	4,310	+285	+7.1%
Brookhaven National Laboratory	5,190	1,982	2,014	+32	+1.6%
Total, Chicago Operations Office	12,887	8,107	8,424	+317	+3.9%
Idaho Operations Office					
Idaho Operations Office	18,795	19,371	22,127	+2,756	+14.2%
Idaho National Engineering and Environmental Laboratory	500	500	875	+375	+75.0%
Total, Idaho Operations Office	19,295	19,871	23,002	+3,131	+15.8%
Oak Ridge Operations Office					
Oak Ridge Operations Office	2,400	2,500	1,000	-1,500	-60.0%
Office of Scientific and Technology Information ..	4	8	8	0	0.0%
Oak Ridge National Laboratory	16,273	19,048	22,770	+3,722	+19.5%
Total, Oak Ridge Operations Office	18,677	21,556	23,778	+2,222	+10.3%
Richland Operations Office					
Pacific Northwest National Laboratory	700	570	950	+380	+66.7%
Oakland Operations Office					
Lawrence Berkeley National Laboratory	478	1,305	1,700	+395	+30.3%
Lawrence Livermore National Laboratory	850	1,500	2,000	+500	+33.3%
Total, Oakland Operations Office	1,328	2,805	3,700	+895	+31.9%
Nevada Operations Office	0	1,500	1,500	0	0.0%
Morgantown Energy Technology Center	0	200	200	0	0.0%
Pittsburgh Energy Technology Center	5,602	4,862	1,200	-3,662	-75.3%

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	\$ Change	% Change
Federal Energy Technology Center	0	1,250	0	-1,250	-100.0%
Headquarters	52,366	46,561	82,707	+36,146	+77.6%
Subtotal, Solar and Renewable Resources Technologies	294,351	336,000	398,921	+62,921	+18.7%
Adjustment	-24,447	0	-821	-821	0.0%
Total, Solar and Renewable Resources Technologies	269,904	336,000	398,100	+62,100	+18.5%

Site Description

Albuquerque Operations Office

Albuquerque Operations Office (ALO) is a Department of Energy Office located in Albuquerque, New Mexico. ALO provides procurement services and oversight of funding for work being conducted at Golden Field Office, Los Alamos National Laboratory, National Renewable Energy Laboratory, Sandia National Laboratories, and the six DOE Regional Support Offices located in Atlanta, GA, Boston, MA, Chicago, IL, Denver, CO, Philadelphia, PA, and Seattle, WA. AL also administers the Solar and Renewable Energy Photovoltaic Energy Systems Program.

Los Alamos National Laboratory

Los Alamos National Laboratory (LANL), located in Los Alamos, NM. LANL conducts research on the Electric Energy Systems High Temperature Superconductivity Program and the Hydrogen Research Program. LANL supports the Electric Energy Systems High Temperature Superconductivity Program by working to develop more efficient electrical transmission and distribution cables, power transformers, and large motors for industrial use. LANL is also studying the use of flywheel energy systems for efficient storage of electricity.

LANL serves as the lead laboratory in the research and development of proton exchange membrane fuel cells for direct hydrogen applications. This includes the application of new material systems, components, and construction techniques to meet the efficiency and cost targets associated with their industry CRADAs. LANL has developed a number of critical technologies for the most advanced fuel cell stacks.

Sandia National Laboratories

Sandia National Laboratories (SNL), located in Albuquerque, NM, Livermore, CA and Tonapah, NV, perform research for the Concentrating Solar Power, Photovoltaic Energy Systems, Geothermal Energy

Systems, Wind Energy Systems, Electric Energy Systems Energy Storage Systems, and the Solar Building Technology Research Programs. SNL serves as the lead laboratory in the development of reliable, economically-competitive, Concentrating Solar Power (CSP) technologies. SNL serves as the primary engineering and testing site for the CSP Program by operating the National Solar Thermal Test Facility (NSTTF). NSTTF covers 110 acres and includes five distance test areas: the Central Receiver Test Facility with a central tower and 222 heliostats; the Modular Solar Industrial Retrofit Trough Facility; the Engine Test Facility; and the Distributed Receiver Test Facility with two 75-kilowatt parabolic dishes. DOE has designated the NSTTF and the Solar Furnace as National User Facilities where qualified researchers from industry, academia, and other laboratories can use the facilities, making it possible for high-risk, high-payoff technologies to be developed and tested.

SNL supports the Photovoltaic Energy Systems Program with the principal responsibility for crystalline cell research, concentrating collector development, and systems and balance-of-systems technology development. Cell research activities support promising new concepts and innovative device fabrication techniques. Indoor and outdoor measurement and evaluation facilities provide support to industry for cell, module, and systems measurement, evaluation and analysis. Systems level work concentrates on application engineering, database development and technology transfer.

SNL serves as the lead laboratory for coordination of the Geothermal Drilling research. In cooperative projects with the U.S. geothermal industry, SNL performs research on advanced drilling systems, drilling measurement and control, drilling hardware development, and design and testing of high-temperature wellbore instrumentation. SNL coordinates the activities of universities and commercial research firms to rapidly bring promising geothermal drilling and instrumentation technologies to commercial availability.

The SNL Wind Energy Department staff work closely with counterparts at the National Renewable Energy Laboratory to provide the Wind Energy Systems Program and the U.S. wind industry with engineering expertise to further the program's knowledge and goals.

In support of the Electric Energy Systems Energy Storage Systems Program, SNL develops improved energy storage systems components including power conversion electronics and modular multi-functional energy storage systems. SNL characterizes the performance of integrated systems with customer-site data collection and identifies and evaluates the benefits of storage technologies in specific applications. SNL cooperates with industry partners in implementing the Program to increase awareness of the benefits of energy storage and options of providing storage alternatives.

As the lead engineering laboratory for the Solar Buildings Technology Research Program, SNL works with manufacturers to assist them in lowering the cost of solar products by introducing advanced manufacturing practices. SNL also provides technical support to assist builders and utilities in overcoming problems with the design or installation of solar water heating systems.

National Renewable Energy Laboratory

The National Renewable Energy Laboratory (NREL) located in Golden, Colorado, conducts fundamental and applied materials research on photovoltaic devices, photovoltaic module and systems development, data collection and evaluation on solar radiation, and cost-shared government/industry partnerships for the Photovoltaic Energy Systems Program. Basic research teams investigate a variety of photovoltaic materials, such as amorphous silicon, polycrystalline thin films, high-efficiency materials and concepts,

and high-purity silicon and compound semiconductors. NREL conducts simulated and actual outdoor tests on photovoltaic cells, modules and arrays. The test results are used in developing standards and performance criteria for industry.

NREL is the lead laboratory for the National Wind Energy Systems Program performing research in aerodynamics, structural dynamics, and advanced components and control systems related to wind energy. The National Wind Technology Center, located at NREL, provides research and testing facilities for fatigue testing of turbine blades, dynamometer testing of control and generator systems, atmospheric testing of turbines, and certification testing which is required for sales and operation in western Europe.

NREL serves as the lead laboratory supporting industry's development of biomass power technologies. These technologies include those based on combustion and gasification of biomass feedstocks. NREL is responsible for the development of advanced analytical methodologies (chemical and life-cycle) that are used to facilitate industry commercialization. These analyses include complete economic assessments of the relevant biomass technologies. NREL works with industry and academia to arrive at consensus points on technology costs and environmental performance. NREL also developed and operates a Thermochemical Users Facility. This state-of-the-art facility enables the private sector to cost-effectively test their power generating technologies and unit operations in a fully-instrumented pilot facility.

NREL is the lead laboratory for the Biofuels-Transportation Program. The Laboratory conducts biotechnology research and engineering development of biological systems for the conversion of biomass to fuels and chemicals, such as ethanol. Also, the Biofuels Program has established the Alternative Fuels User Facility at NREL which includes laboratories, integrated bench scale process equipment, and a one ton per day process development unit.

NREL serves as the lead laboratory for the Solar Buildings Technology Research Program. In this role, NREL coordinates tasks with the Sandia National Laboratories and directs technical tasks that are subcontracted to universities and industry. The primary goal of this program is to develop a low cost solar water heater. NREL also has research tasks to explore solar applications such as crop drying, absorption cooling, space heating, and solar lighting. NREL supports cooperative solar projects with builders and utilities by providing technical information about solar water heaters to the builders and utilities and receiving input from them to help guide the research program.

NREL also provides on-going research and development for the Geothermal Energy Systems, Electric Energy Systems and Storage, and the Concentrating Solar Power Programs.

Golden Field Office

The Golden Field Office (GO) located in Golden, CO, provides procurement services and oversight of work being performed at the National Renewable Energy Laboratory, as well as administering and managing projects for the Biomass/biofuels Energy Systems Program, the Electric Energy Systems and Storage Program, the Photovoltaic Energy Systems Program, the Concentrating Solar Power Program, and the Renewable Energy Production Incentive Program. Go manages Gasifier demonstration projects to advance technologies to convert biomass-wood and agricultural stock and waste into electricity.

GO manages the Superconductivity Partnership Initiative (SPI) for the Electric Energy Systems High Temperature Superconductivity Program. The SPI is 50% cost-shared with industry and consists of six

projects to develop first-of-a-kind designs for more efficient power cables, transformers, industrial motors and flywheel energy systems.

GO manages two projects for the Photovoltaic Energy Systems Program, which are designed to increase market penetration and integrate PV product development. These projects are the Technology Experience to Accelerate Markets in Utility Photovoltaics (TEAM-UP) and the Building Opportunities in the United States for Photovoltaics (PV:BONUS) programs. GO utilizes cooperative agreements and requests for proposals to help industry realize the benefits of using photovoltaic systems and devices.

GO works with DOE program managers in the overall operation and management of the Concentrating Solar Power Program, including the contractual relations with industry partners. GO manages the Solar Two Project in Barstow, CA, and participates in the Solar Two Consortium. GO project managers are responsible for all technical and contractual requirements associated with the successful conduct and completion of the Solar Two Project.

GO is the lead office for the administration of the Renewable Energy Production Incentive (REPI) Program. REPI encourages the acquisition of renewable energy generation systems by state and local governments and non-profit electric cooperatives by providing financial incentive payments for energy generation systems which use solar, wind, geothermal or biomass technologies.

Chicago Operations Office

The Chicago Operations Office (CH), located in Argonne, IL, provides procurement services and oversight of funding for work being performed at Argonne National Laboratory and Brookhaven National Laboratory. CH also administers Solar and Renewable Energy programs such as the Biomass/biofuels Energy Systems and the Hydrogen Research Programs.

Argonne National Laboratory

Argonne National Laboratory (ANL), located in Argonne, IL, performs research and development for the Electric Energy Systems High Temperature Superconductivity Program to help in the development of more efficient electrical transmission and distribution cables, power transformers, and large motors for industrial use.

Brookhaven National Laboratory

Brookhaven National Laboratory (BNL), located on Long Island, NY, performs research and development for the Electric Energy Systems High Temperature Superconductivity (HTS) Program, and the Photovoltaic Energy Systems Program. BNL supports the HTS program by working with National Laboratory/industry teams and universities to undertake research on fundamental wire processing and application issues.

BNL has the responsibility for environmental, health and safety (ES&H) impacts associated with photovoltaic energy production, delivery and use. BNL conducts ES&H audits, safety reviews and incident investigations, and assists industry to identify and examine potential ES&H barriers and hazard

control strategies for new photovoltaic materials, processes and application options before their large-scale commercialization.

Idaho Operations Office

The Idaho Operations Office (ID), located in Idaho Falls, ID, provides procurement services and oversight of funding for the Idaho National Engineering and Environmental Laboratory. ID also administers Solar and Renewable Energy programs such as the Renewable Indian Energy Resources and the Hydropower Programs, and is the principal field administrator of the Geothermal Energy Systems Program.

Idaho National Engineering and Environmental Laboratory

Idaho National Engineering Laboratory (INEEL), located in Idaho Falls, ID, performs research and development for the Hydropower and Geothermal Energy Systems Programs. INEEL has been the principal DOE laboratory for the Hydropower Program since the program's inception in 1977. INEEL serves as the engineering technical monitor for the Advanced Hydropower Turbine System Program and the Renewable Indian Energy Resources hydropower projects located in Alaska.

INEEL serves as the lead laboratory for coordination of the Geothermal Exploration and Geothermal Reservoir Technology research. In cooperative projects with the U.S. geothermal industry, INEEL performs research on fluid flow and solute transport modeling in hydrothermal reservoirs and conducts site investigations of geothermal resource potential. INEEL coordinates and interacts with other National Laboratories, universities, and commercial research institutions to consolidate their contributions to the research and technology development and thereby increase the utilization of geothermal energy resources.

Oak Ridge Operations Office

The Oak Ridge Operations Office (OR), located in Oak Ridge, TN, provides procurement services and oversight of funding for the Oak Ridge National Laboratory and the Office of Scientific and Technology Information. OR also administers the Solar and Renewable Energy Biomass/biofuels Energy Systems Program.

Office of Scientific and Technology Information

The Office of Scientific and Technology Information (OSTI), located in Oak Ridge, TN, performs standard distribution for all programs under the Office of Power Technologies including: Photovoltaic Energy Systems; Concentrating Solar Power; Biomass/biofuels Energy Systems; Wind Energy Systems; Geothermal Energy Systems; Hydrogen Research; and the Electric Energy Systems High Temperature Superconductivity Programs. This distribution consists of publishing and maintaining on-line full text of eight electronic current awareness publications and the production of CD-ROM disks containing Photovoltaic reports.

Oak Ridge National Laboratory

Oak Ridge National Laboratory (ORNL), located in Oak Ridge, TN, performs research and development on the Electric Energy Systems Transmission Reliability, the Biomass/biofuels Energy Systems, and the Hydropower Programs. ORNL is part of a national laboratory/industry/university consortium that was formed to support research in Transmission Reliability of electric energy systems. This consortium is a new initiative for fiscal year 1999. It is anticipated that ORNL will perform electric power system studies related to the impact of distributed resources on electric power distribution systems, perform an assessment of the technology and R&D control needs for real time system control, and assist in designing a test bed for field or simulation testing of distributed resource concepts.

ORNL manages the Bioenergy Feedstock Development Program (BFDP) to develop new and improved sources of biomass feedstocks for biomass energy systems. ORNL provides technical leadership for the program and actively fosters alliances among universities, other government agencies and industry. Major current components of the BFDP include energy crop development, environmental research, residue and forests research, resource economics, demonstration project support and evaluation, and communication. These efforts compliment the National Renewable Energy Laboratory and the Sandia National Laboratories' programs.

ORNL has the primary responsibility for environmental analysis and is the environmental technical monitor for the Advanced Hydropower Turbine System Program. This includes the technical oversight of laboratory biological experiments on stresses experienced by turbine-passed fish.

Richland Operations Office

The Richland Operations Office (RL), located in Richland, WA, provides procurement services and oversight of funding for the Pacific Northwest Laboratory.

Pacific Northwest National Laboratory

Pacific Northwest National Laboratory (PNNL), located in Richland, WA, performs some on-going research for the Hydrogen Research Program.

Oakland Operations Office

The Oakland Operations Office (OAK), located in Oakland, CA, provides procurement services and oversight of funding for the Lawrence Berkeley and the Lawrence Livermore National Laboratories.

Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory (LBNL), located in Berkeley, CA, performs analyses of opportunities for wind energy applications in the restructured electricity market and administers various utility restructuring activities. In support of utility restructuring, LBNL conducts policy and technical

analyses on utility regulatory policies at the state and federal levels. LBNL provides technical support to state organizations such as the public utility commissions and state energy offices on utility restructuring issues. LBNL provides guidance and support to the private and public market components of the utility industry, including the energy services industry, regional market transformation consortia, and public and private utilities.

LBNL also supports the analyses and proposed implementation of the Administration's proposed legislation on utility restructuring.

Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory (LLNL), located in Livermore, CA, performs research and development for the Hydrogen Research Program. LLNL serves as the lead laboratory in the research and development of a high temperature solid oxide electrolyzer and two different systems for pressurized gas storage of hydrogen. LLNL is developing the materials and technical and engineering data on the preferred configuration for a solid oxide system that will simultaneously reform natural gas to hydrogen using the waste heat for a higher round trip efficiency. LLNL is capable of producing composite storage tanks for environmental testing to verify the advantages of various engineering concepts designed to increase storage capacity while reducing the costs of manufacturing the tanks.

Federal Energy Technology Center

The Federal Energy Technology Center (FETC) provides research and development on Solar and Renewable Energy programs with a major emphasis on the Hydrogen Research Program and some on-going research for the Biomass/biofuels Energy Systems Program. FETC will administer a cooperative agreement with Virginia Accelerator Corporation for an electron scrubbing demonstration project.

Headquarters and All Other Sites

The Office of Energy Efficiency and Renewable Energy (EE) funds research at six regional support offices located in Atlanta, GA, Boston, MA, Chicago, IL, Denver, CO, Philadelphia, PA, and Seattle, WA, and also provides funding at DOE Headquarters for various Solar and Renewable Energy procurements and interagency agreements in support of the EE mission.

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	\$ Change	% Change
General Plant Projects	1,000	1,869	750	-1,119	-59.9%
General Purpose Equipment	0	2,031	350	-1,681	-82.8%
Total Operating Expenses	1,000	3,900	1,100	-2,800	-71.8%

Construction Projects

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp- riations	FY 1998	FY 1999	FY 2000	Unapprop- riated Balance
96-E-1000 FTLB Expansion and Renovation Project, NREL	6,500	4,300	2,200	0	0	0
Total Construction	6,500	4,300	2,200	0	0	0

Solar Building Technology Research

Mission Supporting Goals and Objectives

Program Mission

The mission of the Solar Buildings Technology Research Program is to conduct research essential to the development of advanced solar thermal building technologies. These technologies can significantly contribute to the domestic energy needs of the United States.

The program supports DOE's mission to foster a secure and reliable energy supply that is environmentally sound and economically sustainable.

Program Goals and Objectives

The primary goal of the Solar Building Technology Program is to reduce the system cost and improve the reliability of solar water heating. The objective is to reduce the life-cycle cost from today's \$0.08/kWh (thermal equivalent) to \$0.04/kWh by FY 2003.

Achieving this goal will make solar water heaters increasingly competitive in the residential market and reverse the trend that has

seen their annual sales decrease from over 100,000 in the early 1980's to less than 8,000 in 1997. A second goal is to increase builder and consumer confidence in solar technology as it is applied to residential, commercial, and industrial buildings. There are two objectives supporting this goal: (1) assisting industry in the establishment of performance and reliability standards accepted throughout the U.S.; and (2) understanding the needs of builders and consumers.



Strategic Approach

This Program will be implemented in partnership with manufacturers, equipment suppliers, and installers.

The existing solar thermal industry, however, consists of small, under-capitalized companies which do not have the capital resources or in-house technical expertise to overcome significant technical and market barriers presented by the fragmented infrastructure of builders, suppliers and consumers.

Another part of the program's strategy is to work closely with Federal agencies (e.g. HUD's *Partnership for Advancing Technology in Housing*) and state energy offices (e.g. California Energy Commission).

Cost sharing from government, utility, builder, and solar industry partners should be approximately \$2,000,000 in FY 2000.

The Program's strategic approach consists of three key activities which will lead to cost competitive solar water heaters and increased consumer confidence in the technology: quality assurance, precompetitive field validation, and technology development.

Quality Assurance - The program will support development of models that estimate technology performance and reliability. These models will be the basis for voluntary national standards for solar water heating systems.

Precompetitive Field Validation - The program will work with builders, utilities, and energy service companies to identify the improvements necessary to make solar technology fully acceptable for the residential construction and commercial building markets. It will use their input to guide the program's R&D activities and validate those improvements through cost-shared field tests.

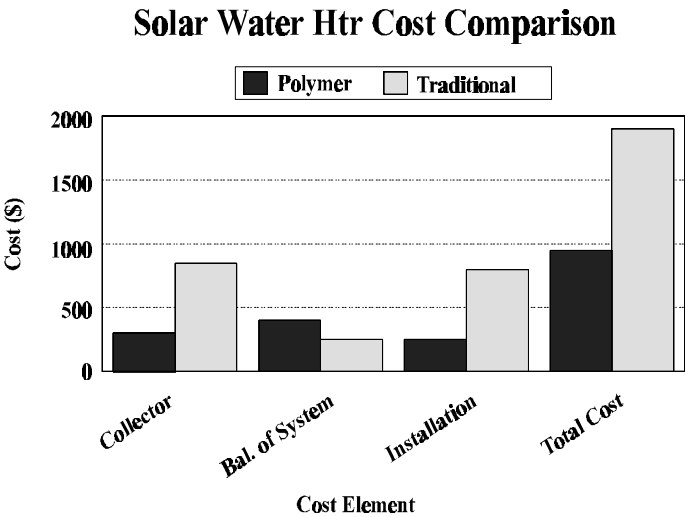
Technology Development - The major thrust for the program will be focused on developing a new generation solar water heater that reduces the cost and increases the service life of the technology. Contracts with universities and industry provide the mechanism for the new technology. Cost reductions will be realized through improved manufacturing processes, the use of less expensive materials (see chart), innovative design, and better integration of the solar collector into the building. This activity is supportive of recommendations by the President's Committee of Advisors on Science and Technology to establish an initiative on low cost solar water heaters. This also supports DOE's strategic goal of promoting the development of competitive and environmentally sound energy markets in the U.S. In addition, R&D would explore the feasibility of solar lighting (i.e. using fiber optics or light pipes to bring solar light into interior rooms).

Program Benefits

At the proposed funding levels, the Solar Building Technology Research Program is expected to yield the following benefits:

Metrics	FY 2000	FY 2010	FY 2020
Primary Energy Displaced (Quads).....	0.00	0.03	0.11
Energy Savings (\$ Billions).....	0.00	0.15	0.75
Carbon Displaced (MMTCE).....	0.05	0.47	1.70

These benefits are derived from displaced energy consumption in residential and commercial buildings which collectively consume approximately a third of the primary energy used in the U.S. The Solar Buildings Program addresses a market that consists of 95 million households, 4.5 million commercial buildings, 9 million pools and spas, and 750,000 industrial processes that use steam at temperatures less than 400F. An estimated 1.2 million solar domestic water heaters have been installed in the U.S. with an additional 500,000 expected by 2010. Each system provides approximately 3000 kWh per year thermal equivalent (10 MBTU/year). By the year 2020, solar energy could displace 0.11 quads of the thermal



energy needed by the buildings market. Reducing the use of fossil fuels by that amount would improve the quality of our air, and reduce greenhouse gas emissions by 1.70 MMT (carbon equivalent).

Performance Measures

FY 2000 Performance Measures

- # Achieve \$0.07 per kWh (projected delivered energy cost) for solar water heating systems through improved manufacturing processes.

FY 2001-2006 Performance Measures

- # Achieve \$0.04 per kWh (projected delivered energy cost) for solar water heating systems due to low cost *next generation* solar water heating technology.

Significant Accomplishments and Program Shifts

Pre-FY 1998 Accomplishments

- # In collaboration with the Solar Rating and Certification Corporation developed procedures for the voluntary industry certification of solar energy equipment to provide performance verification.
- # Provided technical and field monitoring assistance to industry, Federal, and state governments for the installation of hundreds of solar water heating systems since the late 1970's. The performance history of some of these systems will be used to help develop reliability standards.
- # Developed solar domestic hot water systems with levelized energy cost of \$0.08/kWh, a reduction from about \$0.20/kWh in the mid 1980's.
- # Developed transpired collector technology for preheating building ventilation air with levelized energy cost of \$0.04/kWh and 30 year lifetimes.

FY 1998 Accomplishments

- # Support was provided to expand the rating and certification procedures for new system designs being developed by industry.
- # A Cooperative Research and Development Agreement was initiated with the Salt River Agricultural Improvement and Power District to develop a low cost solar water heater. Cooperative projects were also established with Eugene Water and Electric Board and Lakeland Electric and Water. Similar solar water heating projects were established with several builders: including Pulte Homes and CAVCO Industries. Technical support (e.g. system evaluation) was provided to each. In addition, a study concluded that builders were concerned about the cost, aesthetics, and reliability of solar water heaters. Another study indicated considerable interest in solar water heaters among potential home buyers if a reliable, low cost system was an option.
- # Completed the first phase of four contracts with solar manufacturers, which identified and quantified manufacturing improvements that could lead to cost reductions up to 20%. Selected contracts for phase 2, which will assist the manufacturers in implementing improvements in welding, system control, and component design.

- # Completed first phase of seven industry and three university contracts selected to evaluate concepts that have the potential to significantly reduce solar water heating costs. Concepts included freeze and overheating protection, polymer based systems, and use of heat pipes that could eliminate the need for pumps and controllers. It was shown that polymer materials have been developed which have the potential for withstanding high temperature and exposure to solar radiation. These polymers would replace the copper and glass that make up present solar water heaters. In addition, designs were developed which simplify the systems by eliminating the need for pumps and controllers, thus making the systems potentially more reliable.
- # A Cooperative Research and Development Agreement (CRADA) with Energy Laboratory, Inc. (ELI) led to the development of *Black Crystal*, a selective absorbing coating for solar heat collectors that has the potential for replacing black chrome as the industry standard. Black Crystal does not have the environmental problems associated with chrome and can be produced with a fraction of the energy.
- # Completed evaluation of four solar absorption A/C concepts. Studies completed during FY 1998 indicate that further solar absorption cooling R&D is not warranted at this time.

FY 1999 Planned Accomplishments

- # Complete development of a standardized wind loading rating for solar collectors on roofs.
- # A task will be initiated to develop models that can be used to establish reliability standards for solar water heaters.
- # Universities and industry will complete feasibility studies of ten solar water heater concepts exploring the use of low cost materials (e.g. lightweight polymers which offer savings in the cost of the collector and its installation) and components (e.g. heat pipes which could lower cost by eliminating the need for pumps and controllers, and increasing system reliability). The best of these will form the basis of the *next generation* solar water heaters. Prototypes will be built and tested in the laboratory to determine their performance under a variety of simulated weather conditions. Accelerated tests will be conducted to predict the longevity of the polymer components; a critical question that must be answered. Existing methods of predicting the lifetime of polymers, however, are unable to predict as far into the future as the 10 to 15 years (minimum) that the solar system must work. Research will begin at NREL on developing an *Ultra accelerated* method of predicting polymer lifetime.
- # Implement manufacturing improvements that will lead to solar technologies capable of producing hot water at \$0.07/kWh.
- # Continue the Cooperative Research and Development Agreement with the Salt River Agricultural Improvement and Power District (SRP), whose goal is to develop a solar water heater that could provide hot water at a levelized cost of \$0.06 to \$0.07/kWh. Provide technical support to other utilities and builders that have established solar water heating programs. This effort is limited to technology development and includes system evaluation, analysis of system performance, and assistance in solving problems such as materials degradation that industry is incapable of solving by itself.

FY 2000 Planned Accomplishments

- # Expand existing certification procedures to include reliability standards.

- # Complete the collaborative projects with utilities and builders established during FY 1998 and assess their impact on improving solar water heating technology. Complete CRADA with Salt River Project that has potential to reduce cost of solar water heat to \$0.06/kWh.
- # Achieve \$0.07/kWh (projected delivered energy cost) for solar water heating systems through improved manufacturing processes.

FY 2001-2004 Planned Accomplishments

- # Assist industry and state led efforts for the development of voluntary national installer certification standards and licensing procedures to assure quality installations of systems.
- # Work with builders and utilities to test prototype *new generation* solar water heaters. This would include systems instrumented to obtain data concerning long term performance & reliability, materials & component longevity, and performance in a variety of climates.
- # In collaboration with industry, develop next generation of solar equipment to provide reliable energy at \$0.04/kWh for solar water heating.

Program Completion

Successful completion of the Solar Building Technology program will be attained when the Program's cost goal is reached (\$0.04/kWh levelized life-cycle cost). It is expected that attaining this goal will make solar water heaters competitive with electric water heaters in many areas of the U.S. and natural gas water heating in some areas. As important, however, this translates to a family being able to purchase a solar water heater for about \$1,000 and realizing a payback of that investment in about 4 years.

Funding Schedule

	(dollars in thousands)				
	FY 1998	FY 1999	FY 2000	\$ Change	% Change
Space Conditioning and Water Heating.....	2,625	3,600	5,500	1,900	52.8%
Total, Solar Building Technology Research.....	2,625	3,600	5,500	1,900	52.8%

FY 1998	FY 1999	FY2000
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Detailed Program Justification

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Solar Building Technology Research

Quality Assurance - The Solar Rating and Certification Corp (SRCC) will complete the task to make U.S. solar water heater standards compatible with international standards, thus enabling U.S. companies to more easily compete in international markets. Information related to problems associated with residential solar water heating systems in California, Oregon, and Florida will be put into a database and used to help in the development of reliability standards.

The establishment of solar industry reliability standards for solar water heating systems will compliment the performance standards already established. It will benefit manufacturers by providing them information on which parts of their solar water heating system need improvement and will provide consumers information that will enable them to trade-off cost with performance and reliability. Consumer confidence in solar technology is necessary if DOE is to achieve its mission of developing solar energy as a reliable, environmentally sound option. This activity will continue through 2005. Its focus will evolve from developing performance standards to developing reliability standards and standards for installers of solar water heating systems that can be used as guidelines by states. The funding level is estimated to be sufficient to support the establishment of the reliability standards. This is based on experience in developing performance standards.

140 100 300

Precompetitive Field Validation - Cooperative projects with utilities and builders will be continued to eliminate technical barriers that limit the use of solar water heaters. A CRADA with Salt River Project will be completed that develops a lower cost, roof integrated solar water heater. Technical support to Pulte Homes and CAVCO Industries will be provided.

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Cooperative agreements with utilities and builders help maintain relationships that are important because they provide data from Areal-life@systems that are not duplicated by researchers and engineers under controlled test conditions at NREL and Sandia. This data helps guide technology development activities and insures that the technology will satisfy the needs of those who sell it, install it, and buy it. This activity will continue through 2005, when the new, low cost solar water heater evaluation is completed. The funding level is determined necessary to support all existing cooperative agreements..

1,005	0	500
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Technology Development - Research will focus on the two concepts which have the greatest potential for achieving the program's cost goal. Both systems are likely to be polymer based. Design improvements will be made to the prototypes tested during FY 1999 and new systems will be built and tested to determine their ability to withstand overheating and freezing. The accelerated lifetime testing of several polymer formulations will continue, as will the development of an Aultra accelerated@method of predicting polymer lifetime. A study will be completed to determine the potential of using fiber optics or light pipes to bring sunlight into the interior of buildings.

This is an R&D effort that is attempting to use new materials and new designs to significantly decrease the cost of solar water heaters. As such, it entails a significant technical risk, but the amount was deemed appropriate for this stage of the research. Industry has indicated it is unable or unwilling to support this type of activity without DOE assistance. It will support the laboratory, university, and industry R&D that made great strides in FY 1998 to place the cost goal within reach. The funding level was determined by the Technology Managers at NREL and Sandia to be the minimum amount necessary for achieving the \$0.04/kWh cost goal by 2003.....

1,480	3,500	4,700
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(dollars in thousands)

	FY 1998	FY 1999	FY 2000
Total, Solar Building Technology Research.....	2,625	3,600	5,500

Explanation of Funding Changes from FY 1999 to FY 2000

	FY 2000 vs FY 1999 (\$000)
Space Conditioning and Water Heating	
# Quality Assurance - Builders and home buyers have emphasized the importance of reliability when considering solar water heaters. The increase would continue the effort begun in FY 1999 to establish voluntary reliability standards as a complement to the existing performance standards.	+200
# Precompetitive Field Validation - A number of builders and utilities have established solar water heating programs. The increase would enable DOE to provide them technical support that is beyond the capability of the solar industry. .	+500
# Technology Development - The technology development program is expanded to reduce the cost of solar water heating technology to \$0.04/kWh or less by FY 2003. Achieving this goal will make it competitive in wide areas of the U.S. This funding supports university and industry R&D.	+1,200
Total Funding Change, Solar Building Technology Research.....	+1,900

Photovoltaic Energy Systems

Mission Supporting Goals and Objectives

Program Mission

The mission of the National Photovoltaics Program is to conduct the research and development (R&D) necessary to enable photovoltaics (PV) to become a significant contributor to the United States domestic energy needs. The resources dedicated to R&D, in partnership with industry and academia, have advanced PV from a laboratory novelty to a growing U.S. industry that has the worldwide lead, with more than 40% of the cell and module sales. The challenge for the DOE PV program is to continue an effective and productive role in advancing PV technology and maintaining and enhancing a growing U.S. industry.

Program Goals and Objectives

By 2004, in partnership with the photovoltaic industry, universities and national laboratories, the National Photovoltaic Research Development & Deployment (RD&D) Program will 1) increase the efficiency of commercial modules from the current 7% to 12% when made from lower cost thin film materials and from the current 13% to 16% when made from more costly crystalline silicon materials; 2) reduce the retail sales price of commercial modules by 40% from current average costs of about \$4.25/Watt; 3) increase the lifetime of fielded systems from the current 10-15 years to greater than 25 years; and 4) increase the U.S. PV industry cumulative sales of power modules from 265 Mega Watts (MW) in 1997 to 1000MW (U.S. and export sales). These advancements are necessary to develop cost competitive products that can sustain the emerging PV industry and will also ensure successful implementation of the Million Solar Roof Initiative. By the year 2004 we will have reached 60% of the program's technical goals and industry will have introduced products into the market place such that there will be 500MW of cumulative installed systems in the U.S. By the year 2004, based on the current U.S. PV industry growth rate, the U.S. PV industry will have captured 50% of the world market.

In addition to the 5-year goal, the Photovoltaic Program has established near-term (FY 2000) and longer term goals to ensure steady progress and successful implementation of the Program. Success will be attained when photovoltaics can provide more cost competitive electricity than other forms of electrical generation. The PV Program's near-term goal is for PV to produce electricity at \$0.12 to \$0.20/kilowatt hour (kWh) by 2000, based on installed system costs of \$3.00 to \$7.00 \$/Watt and module efficiencies of 10-16%. The longer term goal is to reach \$0.06/kWh electricity with installed system costs from \$2.00 to \$4.00/Watt. PV must also be more reliable and convenient to use than the next best alternative for each application. Therefore, the program is working towards system lifetimes greater than 20 years and with manufacturers to simplify system design and develop uniform standards.

Strategic Approach

The Federal government invests in PV to help establish a domestic energy option that can also protect the environment and foster an emerging high-technology industry that creates high-value jobs. Industry's stake in opening new markets and applications has increased because of rising competition. DOE's strategy is to concentrate on areas of high-risk, high-payoff research and development where private sector companies traditionally under invest and where DOE has the most valuable expertise and can make a significant impact with limited funds.

This strategy includes conducting fundamental research on several photovoltaic semiconductor materials to resolve issues that limit current technology, and to conduct basic R&D for breakthrough, non-conventional PV technologies aimed at dramatic cost/kW reductions. In addition, advanced materials and devices work will continue cost-shared research with industry to improve device efficiency and stability, particularly for large-area thin film deposition systems. Process R&D will be conducted by way of cost-shared industry research (greater than 50% by industry) to reduce module manufacturing costs, improve module performance, and stimulate investment in new manufacturing lines. These research activities are core program efforts to develop the advanced technologies that are essential to maintaining U.S. competitiveness in the next 5 to 10 years. To further support the strategy, module reliability research will be conducted to improve lifetime in the field, and system component reliability efforts will be increased to help improve the lifetime of fielded systems. Efforts to deploy PV systems in cost-shared utility projects designed to establish technical and economic validation in specific high-value applications will also be conducted. In addition, research and analysis relating to restructuring in the electric utility industry will be conducted on issues associated with integration of PV systems into an increasingly competitive industry framework.

In summary, the FY 2000 budget presents a balanced effort in fundamental and applied research, materials and device development, process R&D, module reliability, and system testing and evaluation. A major portion of this work will be undertaken via competitive procurement resulting in highly leveraged cost-shared projects with the emergent PV industry.

This balanced, aggressive set of research activities will maintain industry growth and momentum, two important ingredients necessary to successfully meet program goals. The PV industry lost market share during the 1980's when budgets were reduced. The industry (with Federal research and support) has worked very hard over the past ten years to re-establish small, incremental market increases in spite of strong foreign competition. In 1997, the U.S. PV industry had its largest increase in sales of modules in over a decade, yet could only gain one percentage point in market share, from 43% to 44%. This is significant in two ways: the momentum of the program is at its highest in ten years, but foreign competition is also the strongest it has ever been. The proposed FY 2000 budget will help maintain industry's growth and momentum during a period of strong foreign competition.

The Photovoltaics R&D program is complemented by the Million Solar Roofs Initiative - which seeks to facilitate the installation of photovoltaic and solar hot water systems on one million buildings across our nation by 2010. These installations will result in substantial field experience with this technology by electric utilities, engineers, developers and others and decreases in production costs by manufacturers as market demand increases.

Program Benefits

Metrics	FY 2000	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.00	0.01	0.05
Energy Savings (\$ Billions)	0.00	0.02	0.16
Carbon Displaced (MMTCE)	0.00	0.08	0.72

The U.S. photovoltaic industry has been growing at an average annual rate of 24% over the past eight years and is now the leader in sales throughout the world. In 1997, over 70% of sales were exported to foreign markets. The strong and aggressive DOE R&D Program has been the key to enabling the U.S. PV industry to be the technology and product leader in a very competitive and rapidly growing global marketplace.

In 2010, photovoltaic systems are estimated by McNeil Technologies to produce approximately 3,000MW, the same electricity generating capacity as 3-5 coal-fired plants, which will reduce annual carbon dioxide emissions equivalent to what is now produced by 850,000 cars.

Performance Measures

FY 2000 Performance Measures

- # Increase the conversion efficiency of commercial thin film modules from the current 7% to 10% and from the current 14% to 15% for crystalline silicon.
- # Develop a 13%-efficient stable prototype thin-film module.

FY 2001 - 2006 Performance Measures

- # Test a low-cost, stable module encapsulant compatible with 30-year module life.
- # Achieve greater than 300 megawatts of cumulative installed PV systems in the U.S.
- # Increase the efficiency of commercial thin film modules to 12% and crystalline silicon modules to 16%.
- # Test fielded PV system compatible with 25-year life.
- # Increase the U.S. PV industry cumulative sales of power modules from 265 megawatts in 1997 to one gigawatt.

Significant Accomplishments and Program Shifts

Pre-FY 1998 Accomplishments

- # The first commercial copper indium diselenide (CIS) thin film module at 9.5% efficiency was achieved by Siemens Solar Industries in Camarillo, California.

- # Two new photovoltaic manufacturing plants came online in 1997: a 5MW amorphous thin film plant by United Solar in Troy, Michigan, and a 10MW amorphous thin film plant by Solarex in Virginia.
- # A new photovoltaic roofing shingle was commercialized by United Solar which won awards for best new product of the year by Popular Science and Discovery magazines.

FY 1998 Accomplishments

- # Developed an 18% efficient prototype thin-film solar cell.
- # Achieved retail sales of 8% efficient cadmium telluride (CdTe) large area modules by industry.
- # Established at least 10 State and community partnerships for the Million Solar Roofs Initiative.
- # Two new photovoltaic alternating-current (AC) modules commercialized by Advanced Energy Systems and Ascension Technology won awards for best new product of the year by Popular Science magazine. The modules feature built-in microinverters that allow them to act as their own AC generators.
- # Initiated the government, industry, state and community partnerships to put solar energy systems on one million roofs.

FY 1999 Planned Accomplishments

- # Complete Phase 2 Preliminary Engineering Development and initiate Phase 3 Prototype Development/Field Verification for the PV:BONUS project.
- # Develop 13% efficient stable prototype amorphous silicon solar cells.
- # Develop codes, standards and safety specifications for residential PV roof systems.
- # Support the Million Solar Roofs Initiative by installing 15,000 energy systems and establishing up to 16 additional major partnerships.
- # Complete round 3 projects initiated in FY 1998 under the Partnerships for Technology Introduction and implemented through the Utility Photovoltaic Group (UPVG).

FY 2000 Planned Accomplishments

- # Develop 13% efficient stable prototype thin film module (either CdTe or CIS).
- # Identify 2-4 new and novel materials and cell devices with potential for low cost future generation PV options.
- # Develop low cost options for 35% high efficiency tandem concentrator cell.
- # Identify a low cost, stable module encapsulant compatible with 30-year module life.
- # Install 26,000 solar energy systems in support of the Million Solar Roofs Initiative, bringing the total number of installed systems to 51,000.

Program Completion

Successful completion of the Photovoltaic program will be attained when the cost of PV generated electricity is cost competitive with conventional distributed power generation (\$0.06/kWh). With continued support for a strong and aggressive R&D Program, this goal can be met in the 2010 to 2015 time frame.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	\$ Change	% Change
Fundamental Research	11,000	11,000	20,309	+9,309	+84.6%
Advanced Materials and Devices	24,000	27,000	27,000	0	0.0%
Collector Research and Systems Development	29,691	34,200	46,000	+11,800	+34.5%
Total, Photovoltaic Energy Systems	64,691	72,200	93,309	+21,109	+29.2%

Detailed Program Justification

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Fundamental Research

- # **Measurement and Characterization** - Support industry and university research groups in advancing material and cell technologies by characterizing cell materials and devices, and reducing efficiency limiting defects in cell materials. The funding level is considered appropriate based on laboratory scientific staff experience, and through the development of a comparative analysis with similar research activities. Most PV companies cannot afford large teams with expensive laboratory facilities of their own to conduct long-term, high-risk basic research activities. 5,500 5,500 5,500
- # **Basic Research/University Programs** - Improve the understanding of defects in conventional crystalline silicon and thin film materials that limit efficiency. Support research to advance the understanding of cell material growth, deposition processes, semiconductor theory, and characterization methods and standards. Begin second year of university research on new and novel materials and cell devices. The funding level is considered appropriate based

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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on laboratory scientific staff experience, and through the development of a comparative analysis with similar research activities. Most PV companies cannot afford large teams with expensive laboratory facilities of their own to conduct long-term, high-risk basic research activities.

5,500 5,500 5,500

Non-Conventional Breakthrough R&D - Issue new competitive solicitation on basic R&D for breakthrough, non-conventional PV technologies - liquid cells, polymers, biochemical and biomimetic processes, etc. - aimed at dramatic cost/kW reductions. The funding level is considered appropriate based on laboratory scientific staff experience, through the development of a comparative analysis with similar research activities, and the PV industry's inability to fund long-term basic research on their own.

0 0 4,309

High Performance Advanced Research - Begin High Performance PV Initiative to support research to substantially increase the efficiency of two key photovoltaic technologies: multijunction concentrating cells and large-area, monolithically interconnected thin films. Fundamental research aimed at major innovations is required to essentially double the conversion efficiency of thin films from their current 8-10% to 15-20%, and to increase III-V-based multijunction cells from 30% to 40% under 500X concentration. In-house national laboratory expertise as well as competitive solicitations to universities and industry will be used to conduct innovative research on thin films and provide insights into III-V-based semiconductor material systems and devices.

Research on thin films will include copper indium gallium diselenide (CIGS), cadmium telluride (CdTe), multijunction amorphous silicon with reduced Staebler Wronski effect, film crystalline silicon materials, and multijunction combinations of the above.

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Research on III-V-based material systems will include 2-, 3-, and 4-junction cells made up of gallium arsenide (GaAs), gallium indium phosphide (GaInP), gallium indium arsenide nitride (GaInAsN), and other quaternary materials. Successful development of the 4-junction cell will allow a 33% efficient concentrating module under 500X concentration. Both the enhanced thin film approach and the multijunction III-V approach will yield dramatically reduced dollar per watt values for terrestrial photovoltaics. The funding level is considered appropriate based on staff experience and historical precedence in similar research activities.

0 0 5,000

Total, Fundamental Research.

11,000 11,000 20,309

Advanced Materials and Devices

Thin Film Partnership Program - Pursue efforts within the thin film partnership program to achieve cost-effective thin film technologies by supporting research teams made up of leading scientists from industry, universities and national laboratories, who work together to define and carry out shared activities. Industry and university participants are selected through competitive solicitations. FY 1999 activities will support the second year of 3-year cost-shared contracts with industry to develop a 13% efficient prototype stable amorphous silicon module; solve degradation of copper indium diselenide (CIS) modules due to water vapor ingress; establish reliable high-throughput, high-yield CIS deposition processes to achieve prototype 13% efficient large area modules; and identify stress induced loss mechanisms for cadmium telluride (CdTe) based cells. The funding is considered appropriate based on staff experience and historical precedence in similar activities. Developing thin film technologies is a major thrust of the Program and receives the most funding because most scientists agree that thin film technologies have the best chance for attaining the Program's long-term goal of \$0.06/kWh.

0 0 19,000

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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# Increase funding for 4-5 additional Thin-Film Partnership industrial contracts. Achieve 13% efficient stable amorphous silicon cells; 10% stable amorphous silicon modules; and a large increase in the commercial production of 8.5% efficient CdTe thin film modules. The funding is considered appropriate based on staff experience and historical precedence in similar activities. Developing thin film technologies is a major thrust of the Program and receives the most funding because most scientists agree that thin film technologies have the best chance for attaining the Program's long-term goal of \$0.06/kWh. . . .	16,000	19,000	0
# Crystalline Silicon/High Efficiency Devices and Reliability Support research on silicon defects and high efficiency devices. Work with high efficiency concentrator cell industry to develop low cost options for 35% tandem cells. Develop innovative silicon crystal growth methods with improved throughput, conversion efficiency, and lower energy and materials cost than current methods. Conduct environmental stress testing of emerging PV modules developed through Thin Film Partnership and PVMaT programs. The funding level is considered appropriate and represents core program efforts to develop the advanced technologies that are essential to maintaining U.S. competitiveness and attaining near; mid- and long-term goals.	8,000	8,000	8,000
Total, Advanced Materials and Devices.	24,000	27,000	27,000

Collector Research and Systems Development

- # **Manufacturing R&D** - Complete second year and begin third year of 3-year Photovoltaic Manufacturing Technology (PVMaT) contracts to accelerate cost reductions and produce higher performance modules. These contracts address manufacturing R&D related to PV system components other than modules, such as batteries and inverters, to improve and reduce overall system costs. Issue a new competitive solicitation in FY 2000 to develop new material and insitu process diagnostics needed for PV module scale-up and successful manufacturing.

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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All new contracts will exceed 50% cost-sharing. The funding is considered appropriate based on an extensive industry-wide survey that concluded that PWMat is the single most effective project that assists U.S. industry in reducing costs. Industry cost-sharing averages 40% (small business: 30%; large business: 50%) which further substantiates industry's support.

0	0	16,000
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- # Fully fund 15-18 new three year PVMaT contracts to improve module manufacturing processes. These contracts are expected to achieve manufacturing cost reductions of 50% from 1996 levels. Completed third year of PVMaT three-year contracts initiated in FY 1996 to reduce manufacturing costs and improve processing of thin film technologies and balance of system components. Awarded additional three-year contracts that emphasized advanced manufacturing technologies for producing higher performance and lower cost commercial thin film and thin silicon modules.

9,000	10,600	0
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- # **Systems Engineering & Reliability** - Conduct system engineering tests to validate the performance, safety, reliability and cost of fielded systems and components. Support development of domestic and international standards and codes, and procedures for certifying performance of commercial systems. Achieve fundamental understanding of photo/thermal/chemical/environmental factors that influence the stability of encapsulated materials and performance of PV cells in modules. Provide \$1,500,000 to support ongoing research at the SE and SW regional experiment stations.

Systems engineering and reliability research is critical to achieving the Program's goal of developing modules and systems that can last 30 years in the field. Cost competitiveness for PV generated electricity is directly dependent on payback over the life of the system under actual operative conditions. The funding level is considered appropriate based on the critical role system reliability plays in the success of the Program.

0	0	16,000
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(dollars in thousands)

FY 1998	FY 1999	FY 2000
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# Support efforts to develop codes, standards and safety specifications for building integrated residential and commercial systems. Continue efforts to evaluate and monitor utility grid tied systems. Maintain reliability research to improve system component performance and reduce O&M costs. Collaborate with U.S. industry to increase system and balance-of-systems efficiency and reliability to achieve additional cost-reduction of about 35% for installed systems in the year 2000 (a savings of about \$2.50 per watt from the present \$8.00 per watt for installed systems) and resulting from improved design, efficiency and quality control.	12,387	16,000	0
# PV Building Integrated R&D - Complete Phase 3 Prototype Development/Field Verification contracts for PV:BONUS II. Assess technical progress and marketing contractors' success of PV:BONUS to determine future activities. Increase R&D on advanced PV Building concepts, tools, and modeling procedures in support of industry efforts for technology development/deployment to address technical barriers to expanded markets for PV in the buildings sector. Continue development of PV integrated design concepts and engineering practices to expand use of PV in residential and commercial buildings. The funding is considered appropriate based on a comparative analysis with similar product development R&D efforts, and to successfully complete the multi-year PV:BONUS II project and honor all contractual commitments.	0	0	5,000
# Fund Phase 2 Preliminary Engineering Development contracts for PV:BONUS II and initiate Phase 3 Prototype Development/Field Verification by awarding PV Building Integrated contracts to best Phase 2 performers. Provide technical support for accelerated use of renewables in as many as one million new buildings by 2010. The funding is considered appropriate to successfully complete the multi-year PV:BONUS II project and honor all contractual commitments.	0	2,300	0

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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#	Assessed the performance of installed systems. Completed Phase I Concept/Business Plan Development activity for the initial awardees under PV:BONUS II. Selected most attractive performers for the Phase 2 Preliminary Engineering Development of new PV building integrated products. Conducted generic technology development research to address technology barriers and industry priorities and needs for expanding market opportunities in the building sector. . . .	1,500	0	0
#	Partnerships for Technology Introduction - Complete testing and verification of all utility and residential grid-tied PV systems installed through previous energy partnerships. Issue new competitive solicitation in FY 2000 for highly leveraged projects emphasizing building integrated applications, including public and private school buildings. All new projects will exceed 50% cost sharing. The funding is considered appropriate because efforts to deploy new products and validate them in the field are critical to meeting the Program's goals and strategy to increase user acceptance in the utility sector.	0	0	6,000
#	No new contracts are planned for FY99. The new projects initiated in FY98 emphasizing building integrated applications will be completed and testing and verification activities will be conducted in FY99. Complete fabrication of the eight utility grid-tied PV systems under UPVG. Issue new solicitation for projects emphasizing building integrated applications.	1,804	3,800	0
#	Million Solar Roofs (MSR) Initiative - In FY99, up to 16 additional major Partnerships will be added to the 9 existing Partnerships established in FY98. These 20 to 25 Partnerships have made preliminary commitments to install over 750,000 solar energy systems by 2010. In FY 2000, we will significantly expand work on financing mechanisms, measurement and evaluation, technical standards and infrastructure such as net metering capability in support of the State and Local Partnerships. Technical assistance will be provided to the Partnerships to familiarize them with solar			

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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energy technologies and evaluate their capabilities and limitations and will support consumer education efforts through the Partnerships and in conjunction with utilities. General training and technical assistance will be provided to Partnerships, utilities, industry groups, financial institutions and governmental entities. Establishment of a national MSR registry jointly with state and local governments, utilities and other MSR partners will be fully implemented. The funding level is appropriate based on comparative analysis of similar activities. Also fulfills strategic objectives in Presidential Initiative.

0	0	3,000
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Conduct training workshops on the design, operation, maintenance, and repair of solar technologies. These workshops will be for state and local agencies, builders, designers, and developers. Begin development of an outreach program to educate consumers about solar technology and familiarize them with the MSR initiative. An additional 15 major partnerships will be formed. Partners will be provided technical assistance as needed. The funding level is appropriate based on comparative analysis of similar activities. Also fulfills strategic objectives in Presidential Initiative.

0	1,500	0
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Developed and implemented Million Solar Roofs Action Plan in response to Presidential Initiative. Coordinated activities with other Federal Agencies (e.g. HUD, EPA, DOD). Formed 9 partnerships that include commitments for a total of 506,400 solar roofs by 2010.

5,000	0	0
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Total, Collector Research and Systems Development.

29,691	34,200	46,000
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Total, Photovoltaic Energy Systems.

64,691	72,200	93,309
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Explanation of Funding Changes from FY 1999 to FY 2000

FY 2000 vs FY 1999 (\$000)

Fundamental Research

Increase includes \$4,309,000 for new competitive solicitation on basic research for breakthrough, non-conventional PV technologies aimed at dramatic cost/kW reductions; and \$5,000,000 new High Performance Advanced Research to substantially increase the efficiency of two key technologies: large-area monolithically interconnected thin films, and multijunction III-V based concentrating cells. +9,309

Advanced Materials and Devices

No changes. 0

Collector Research and Systems Development

Increase includes \$5,400,000 to issue new solicitation under PVMaT for insitu diagnostics in PV processing lines resulting in five to seven new contracts with industry; \$2,700,000 to complete Phase III contracts under PV:BONUS II; \$2,200,000 to issue new solicitation emphasizing building integrated applications; \$1,500,000 to establish 16 new community partnerships and increase work on financing, standards and codes, and infrastructure issues. +11,800

Total Funding Change, Photovoltaic Energy Systems. +21,109

Concentrating Solar Power Program

Mission Supporting Goals and Objectives

Program Mission

The Concentrating Solar Power (CSP) Program works with U.S. industry to develop economically competitive CSP technologies which will improve our nation's energy security through greater diversity of supply; reduce greenhouse gas emissions; and create business opportunities for U.S. industry both here and abroad, resulting in jobs for U.S. workers. CSP technologies will be able to take advantage of utility restructuring by providing technology options capable of providing a significant contribution to state-sponsored portfolio standards and system benefit charge (renewable energy incentive) programs.

Solar Dish/Engine System on Display at the Pentagon

- 25kW power
 - Hybrid Stirling (Solar/Natural Gas)
 - Near-term energy cost < 20¢/kWh
-



Program Goals and Objectives

CSP technologies use various mirror configurations to concentrate the heat of the sun to produce electric power. The current CSP Program portfolio contains systems which range in size from the 10-25kW dish/engine demonstration units, for remote and distributed power applications, to the 354MW of parabolic trough systems which have been producing reliable solar power in Southern California for over 10 years. The CSP portfolio also includes power towers, like the 10MW Solar Two plant, which has the unique ability to utilize thermal storage to put "sun in a bottle" for use when the sun is not shining. Because of their use of heat, all CSP technologies can be hybridized with other fuels to provide high-value dispatchable power on demand. These attributes, along with world record solar-to-electric conversion efficiencies, make CSP an attractive renewable energy option in the U.S. Southwest and other sunbelt regions around the world.

Our role at DOE, is to provide innovative and viable technology options that U.S. industry can then take to the marketplace. The five-year goal of the CSP Program is to work with U.S. industry to develop reliable distributed CSP systems (i.e., 4,000 hrs. between failures) and dispatchable systems capable of producing power in the \$0.06 to \$0.08/kWh range. Achievement of these program objectives will further the Comprehensive National Energy Strategy (CNES) goals of (1) improving global environmental quality, (2) providing future generations with a robust portfolio of clean and reasonably priced energy sources, and (3) promoting the development of open, competitive, international energy markets. With MW-scale systems, CSP technologies have the potential to make a significant contribution to DOE's

Strategic Plan objective to develop renewable technologies capable of doubling non-hydroelectric renewable energy generating capacity by 2010.

Strategic Approach

Over the past ten months, the CSP Program has undergone the most significant overhaul in its history, including a change in name (from Solar Thermal Energy Systems to Concentrating Solar Power). All program elements have undergone extensive review and revision, and all members of the CSP Program's constituency have had opportunities to participate. The objective has been to focus resources on activities which are appropriate to the emerging restructured utility environment and which can be carried out in a reasonable time frame with a conservative budget. Management strategies have been revised where needed, and a new five-year plan has been developed. Rather than focus on specific projects, "paths" addressing core program priorities have been defined and program elements to support these paths have been identified. The result is a Federal program with an appropriate government role which is enthusiastically supported by industry, in tune with current U.S. electricity trends, and poised to provide a significant contribution to the nation's energy needs. FY 2000 is the first budget year for which planning and decision making are guided by the revised program and new multi-year plan, although implementation of the path concept has begun in FY 1999. Program activities are categorized by the four paths described below.

The first path, *Develop and Demonstrate High-Reliability Distributed Power Systems*, initially focuses on improving the reliability of dish/engine systems for emerging markets for distributed energy sources. Distributed power refers to power generated close to the point of demand. These markets currently support remote power prices that can exceed \$0.30/kWh. Activities undertaken on this path will result in orders of magnitude improvements in system reliability, and will achieve energy costs in the \$0.09 to \$0.11/kWh range within six years.

The second path, *Reduce Costs of Dispatchable Solar Power*, includes initial activities in two areas: advanced trough component R&D and the development of high-temperature CSP systems. Dispatchable power refers to power available during periods of peak demand, even when the sun is not shining. Recent trough technology roadmapping exercises with industry have identified opportunities for cost reductions which will provide a leading position for U.S. industry in bidding on international projects currently before the World Bank, and will re-open a domestic market for trough systems. High-temperature system development will take the lessons learned from the Solar Two power tower, which is completing its operation in mid FY 1999, and will apply them to advanced high-temperature component technologies, including those with storage capabilities. Early demonstrations and development efforts, supported by both green power markets and multilateral organizations such as the Global Environment Facility, will lead to a "next generation" of plant designs capable of producing dispatchable power for \$0.6 to \$0.08/kWh within five years. Since these systems are capable of meeting highly-valued daytime peaking power needs, they will be competitive at these prices.

Penetration of broader domestic and international markets will require longer-term research into advanced technologies. This will be covered by Path 3, *Develop Advanced Components and Systems*. Development of advanced technologies (e.g., heat-pipe receivers, high-temperature components, advanced materials), coupled with economies of scale arising from expansion into high-value markets,

will allow CSP systems to compete in dispatchable and distributed markets for \$0.04 to \$0.06/kWh. At these prices, U.S. industry will be able to make CSP systems a self-sustaining component of the energy economy.

In parallel with these three major technology paths, we will also pursue a fourth path which is low in cost, but essential to keeping program activities on track: *Expand Strategic Alliances and Market Awareness*. This path will keep our technology efforts focused on the most critical needs of U.S. industry, ensure a technology capable of meeting market needs, and support domestic and international information flow and policy decisions favorable to renewable energy.

Program Benefits

Metrics	FY 2000	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.00	0.00	0.03
Energy Savings (\$ Billions)	0.00	0.01	0.09
Carbon Displaced (MMTCE)	0.00	0.06	0.42

These benefits correspond to providing enough electricity for 350,000 homes in the year 2000.

Performance Measures

FY 2000 Performance Measures

- # Achieve 1,000 hours of unattended operation on a single dish/engine system in field testing.
- # DOE advanced technology used by U.S. trough team in competitive project bid.

FY 2001 - 2006 Performance Measures

- # Reduce installed costs below \$3,500/kW for dispatchable solar power systems.
- # Achieve 4,000 hours of unattended operation on dish/engine systems in field testing.
- # Validate feasibility and complete conceptual design of high-temperature concentrating solar system capable of generating power for \$0.04/kWh.

Significant Accomplishments and Program Shifts

Pre-1998 Accomplishments

- # Achieved a 29.4% world record solar-to-electric system conversion efficiency with the Advanco dish/Stirling system.
- # The ten-year-old Solar Electric Generating Systems (SEGS) trough plants continue to operate reliably, and through improved O&M technologies and modest design upgrades, produce more energy annually than when new.

- # The Solar Two power tower achieved an instantaneous power production of 11 MW (one MW, or 10%, higher than rated capacity) and demonstrated power production at night using molten salt (solar-on-demand capability).

FY 1998 Accomplishments

- # Solar Two: completed 100 hour acceptance test; generated power continuously for 153 hours (over 6 days) using sun and stored hot salt; and achieved over 1,500 MW and 80% availability over a 30-day period.
- # Installed 2 technology validation 25kW dish/engine systems in the field, including a successful demonstration at the Pentagon.
- # Installed four mass producible heliostats – two at lab sites (for reliability testing and wind load studies) and two in a utility environment.
- # Fabricated and tested hybrid solar/natural gas heat-pipe receiver design for distributed power systems capable of increasing performance by 25% over current direct illuminated receiver (DIR) design.
- # Published initial set of technology characterizations for parabolic troughs, power towers, and dish/engine systems.

FY 1999 Planned Accomplishments

- # 750 hours of reliable operation on a single distributed CSP system.
- # Reduce parasitic power usage at Solar Two from 25MWh to the design goal of 11MWh/day.
- # Developed molten-salt technology improvements which will simplify the process and lessen the cost of energy storage.
- # Developed a lightweight structural facet which will decrease the cost and increase the reliability of concentrators for both distributed and dispatchable solar power systems.
- # The Solar Two Power Tower project, demonstrating the dispatchability of solar power during periods of peak demand, direct funding for this project will be ended. Any further efforts that may be justified will be as part of a new cost-shared contract agreement.

FY 2000 Planned Accomplishments

- # Initiate U.S. Trough Project to develop advanced trough components for near-term applications.
- # Develop and test off-grid capability for remote power systems; install unit on Indian reservation for testing.
- # Build first advanced DECC distributed solar power system; begin field testing.

FY 2001 - FY 2004 Planned Accomplishments

- # Perform reliability testing on distributed solar power systems in the field, achieving 80% availability over a 6-month period.
- # Complete conceptual design of thermal storage option for trough systems.
- # Field-test distributed power systems in a variety of user environments (e.g., end-of-line, land-fill gas sites, remote locations) accumulating in excess of 10,000 hours of on-sun operating data.
- # Scale-up and field-test advanced trough components capable of generating power for \$0.08/kWh).

Program Completion

Distributed power systems must first validate acceptable reliability and operating characteristics in their applications, and then progress with reducing installed costs. Field validations for grid-connected reliability will be completed by 2004, with achievement of 4,000 hours mean time between failures (MTBF). Reliability for off-grid applications will be established by 2006, achieving reliability targets that will be significantly higher than for grid-connected applications. By the year 2004, component cost reduction activities are expected to achieve system designs with energy costs reaching \$0.11/kWh or less in high-volume production; this will be competitive in selected distributed markets.

For CSP technologies competing in dispatchable power markets, the program will achieve cost reductions to \$3,500/kW or less by 2002, and \$3,000/kW or less by 2004. Energy costs will be \$0.08/kWh or less by 2004. The CSP Program will end direct support of the Solar Two power tower in FY 1999. Follow-on activities involving high-temperature component R&D with applications to advanced CSP applications will be initiated. By the year 2003, design specifications will be fixed for the advanced CSP high-temperature systems. These systems will represent the next reduction in costs for the technology. Cost projections for high-temperature systems are in the \$0.04 to \$0.06/kWh range (50% of current dispatchable CSP technology costs). The current trough roadmap defines specific component development programs with high cost-reduction potential.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	\$ Change	% Change
Distributed Power System Development	3,550	5,300	6,700	+1,400	+26.4%
Dispatchable Power System Development	6,850	5,970	5,340	-630	-10.6%
Advanced Component and System Research	5,117	4,990	5,960	+970	+19.4%
Strategic Alliances and Market Awareness	800	740	850	+110	+14.9%
Total, Concentrating Solar Power Program	16,317	17,000	18,850	+1,850	+10.9%

Detailed Program Justification

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Distributed Power System Development

<p># System Reliability – The CSP Program will be working with three industry partnerships to develop and demonstrate reliable dish/engine systems. Under the Utility Scale Joint Venture Project (USJVP), two 25kW systems were built in FY 1998, and a third in FY 1999. All three of these systems will undergo intensive reliability monitoring in FY 1999, and early FY 2000, with a near-term goal of reaching 1,000 hours mean time between failure (MTBF). A second team, under the Dish/Engine Critical Components (DECC) Initiative, began their Phase I design and fielded one 25kW system in FY 1998. In FY 1999, additional components will be assembled and tested, with several full-scale Phase II prototypes to be installed in FY 2000. This activity is built around design improvements that will increase overall system reliability. Cost-share for both of these projects is 50%. A third project was launched in FY 1999 to field an advanced-technology 10kWe solar-powered dish/engine system at a remote, off-grid site in the Southwestern U.S. (e.g., an Indian reservation in Arizona or New Mexico). In FY 2000, the off-grid capability of the system will be developed and tested. These systems will have an early market entry price of less than \$0.20/kWh, and are equally suited for either stand-alone operation or for being hybridized with natural gas or diesel fuel. This funding level, based on program staff experience and analysis of cost-sharing potential, will support the performance and reliability monitoring required to reach the goal of 4,000 hours MTBF, which is essential for commercial viability.</p>	3,550	5,300	5,100
<p># System Testing and Field Validation – Field validation efforts will begin under the USJVP as it enters Phase III, and for the DECC under Phase II, with the opportunity to install multiple systems at sites in the U.S. Southwest. Systems will be installed at different types of user sites (e.g., hybrid dish/engine systems at land-fill gas facilities). This level of funding, based on program staff experience and analysis of cost-sharing potential, will supply the objective data necessary for product improvements aimed at giving U.S. industry a viable distributed solar power option.</p>	0	0	960

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Cost Reduction – The SolMaT Initiative is directed at developing manufacturing techniques to reduce the cost of low-volume production. Distributed SolMaT activities will include manufacturing design improvements, facet production verification, and advanced receiver development. Funding for the early project phases is cost-shared 20% to 35 % with industry. This level of funding, based on program staff experience, is required to initiate these fundamental cost-reduction activities aimed at lowering the cost of manufacturing at low volumes.

0	0	640
3,550	5,300	6,700

Total, Distributed Power System Development.

Dispatchable Power System Development

Cost Reduction – Based on the results of industry’s Trough Technology Roadmapping efforts in FY 1998, a number of component and system improvements were identified as being able to reduce the costs of near-term trough plants from the current \$0.10 to \$0.12/kWh to \$0.06 to \$0.08/kWh. To meet this need, the USA Trough Initiative was launched in FY 1999. FY 2000 work will focus on optimization of the collector design, improved system integration with conventional combined-cycle and heat-recovery plant layouts, and the evaluation of storage concepts. With appropriate R&D, these incremental improvements can collectively have a major impact on near-term costs. The USA Trough Initiative, which is heavily cost-shared by private industry, will provide a leading position for U.S. industry in bidding on international projects currently before the World Bank, with the potential to re-open a domestic market for trough systems. Additional activities include a SolMaT effort to develop low-cost drives and concentrators, and R&D for high-temperature system designs. Independent review boards, such as the President’s Committee of Advisors on Science and Technology (PCAST), support this high-temperature work based on its potential of providing renewable power in the \$0.04/kWh range. This level of funding, based on program staff experience and analysis of cost-sharing potential, is required to develop dispatchable systems capable of producing \$0.06 to

(dollars in thousands)

	FY 1998	FY 1999	FY 2000
\$0.08/kWh power within five years, and prove their long-term potential for costs in the \$0.04/kWh range.	1,700	1,130	3,320
# System Testing and Field Validation – Work will include the field testing of the new parabolic trough concentrator designs. The decreased funding level is due to planned project completion and phase-out of direct Federal support for the Solar Two Project.	3,000	3,360	530
# Reliability and Lifetime Improvement – The recent outstanding performance of some of the Solar Electric Generating System (SEGS) plants has been credited in large part to the O&M improvements achieved through the CSP program. Cost-shared technical support, tracking, and evaluation will be expanded to other sites. Special attention will be given to increasing the lifetime and maintainability of trough receiver tubes. In addition, the Solar Two evaluation and lessons learned document will be completed. This level of funding, based on program staff experience, is required to support the technology and O&M improvements necessary to guarantee the availability of reliable systems for use in near-term markets.	2,150	1,480	1,490
Total, Dispatchable Power System Development.	6,850	5,970	5,340

Advanced Components and Systems Research

# High Efficiency System Designs – Activities include advanced research into high-efficiency system designs that will produce the long-term technological advances required for CSP to compete in both distributed and large-scale dispatchable power markets. Work will include advanced hybrid system designs, investigations of high-temperature working fluids and materials, and the expansion of advanced trough component research. Based on overall budget constraints, this level of funding is required to pursue the most critical technology advances that will drive costs down and move CSP technologies closer to becoming a viable option for U.S. industry to meet the demand for emission-free power. . .	2,698	1,780	1,800
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(dollars in thousands)

	FY 1998	FY 1999	FY 2000
# Field Operations & System Analysis – Funding supports the development of advanced control systems, technology characterization updates, and system modeling. These funds also go to maintain the national laboratory facilities where much of the world-leading solar R&D is conducted. These efforts provide invaluable cost and technical data for each technology and serve as tools for project developers and researchers alike. This level of funding, based on program staff experience, is required to accomplish these tasks.	469	1,410	1,860
# Concentrators – Project work will focus on the development of advanced reflective materials, advanced drives, and concentrator structural design optimization, with applications for both distributed and dispatchable systems. Research will include the development of materials such as the revolutionary ultra-thin glass, which has the potential to greatly reduce the cost and improve the durability of the mirrors. This level of funding, based on program staff experience, is required to accomplish the critical component R&D that will be incorporated in the next generation systems.	1,600	1,220	1,330
# Long-Term R&D – Funding will support the advancement of several existing small projects from the design phase into the development of prototypes. These projects, including thermo-acoustic power and combined CSP and thermo-photovoltaic systems, have the potential to provide reliable distributed power options with the advantage of fewer moving parts, and an inroad into smaller residential markets where on-site power is in demand. This work will evolve to include activities such as heat-absorber materials, high temperature volumetric receivers, and advanced fuels and chemicals applications. The increased level of funding, based on program staff experience, is needed to carry these advanced concepts through the design phase and into working prototypes that get incorporated into advanced CSP systems capable of achieving costs in the \$0.04 to \$0.06/kWh range.	350	580	970
Total, Advanced Component and System Research.	5,117	4,990	5,960

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Strategic Alliances & Market Awareness

# This path covers technology transfer, communication activities, and makes the world renowned technical expertise of SunLab researchers available to U.S. industry, Federal and State legislators, and world organizations involved in renewable energy development. Analyses and studies will be conducted in FY 2000 to ensure that the CSP Program is focused on the needs of industry and the realities of the marketplace. Activities include the development of direct-normal insolation (DNI) maps, technology roadmaps, and web-based communications to make laboratory R&D more accessible to researchers. This level of funding, based on historical staff experience, is required to accomplish these tasks.	800	740	850
Total, Concentrating Solar Power Program	16,317	17,000	18,850

Explanation of Funding Changes from FY 1999 to FY 2000

FY 2000 vs. FY 1999 (000)

Distributed Power System Development

# Increased funding reflects an increase in the number of systems undergoing reliability and field testing as the USJVP, DECC, and Remote Power System projects move into their latter phases.	+1,400
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Dispatchable Power System Development

# Reduced funding for Solar Two, since testing will be complete; offset to some extent by an increase in funding for the USA Trough Project to develop advanced trough components.	-630
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Advanced Component and System Research

# Increase for reflective materials, concentrator structural design improvements, and advanced power conversion systems in order to meet long-term cost goals of \$0.04 to \$0.06/kWh.	+970
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FY 2000 vs. FY 1999 (000)

Strategic Alliances and Market Awareness

# Increase includes additional analysis of domestic markets in order to take advantage of restructuring opportunities.	+110
Total Funding Change, Concentrating Solar Power.	<u>+1,850</u>

Biomass/Biofuels Energy Systems–Transportation

Mission Supporting Goals and Objectives

Program Mission

The mission of the Biofuels Energy System–Transportation program, managed by the Office of Energy Efficiency and Renewable Energy’s Office of Transportation Technologies, is to research, develop, and demonstrate cost competitive technologies for the production of liquid transportation fuels, in collaboration and partnership with industry, other government organizations, academic institutions, and others. In support of this mission, the program pursues the development of low-cost biomass energy feedstocks and cost competitive, highly efficient conversion technologies for liquid fuels production from cellulosic methods. Biomass feedstocks include agricultural residues (e.g., rice straw/husks, bagasse), forest wastes/residues, (e.g., sawdust, thinnings), and energy crops, i.e., trees and grasses grown specifically for use as energy feedstocks. Based on its near-term potential, the program focuses on the production of ethanol.

Program Goals and Objectives

For the ethanol program, production cost goals have been established. The goals provide the direction for the research and development activities supported by the program. By the year 2000, the goal is to demonstrate technologies, in partnership with industry, that are capable of producing ethanol at a cost of \$1.13 per gallon (1996 dollars). This goal applies to green field facilities, although most of the demonstration projects currently under consideration are retrofits of existing facilities or add-ons to biomass power facilities, which significantly lowers the capital investment costs and results in an estimated ethanol production cost of \$0.70 to \$0.90. Currently, three highly leveraged partnerships to build ethanol demonstration facilities have been established. Each of these facilities is being financed with an 80 percent or higher private sector investment and a 20 percent or less DOE cost share. Additional partnerships will be established that will ultimately lead to the design and construction of cellulose-to-ethanol facilities. By the year 2004, at least three ethanol facilities will be in operation using biomass wastes, and a partnership with the corn ethanol industry will complete pilot-scale testing on ethanol production from corn stover. These partnerships are essential components for achieving our programmatic goals in a cost-effective manner.

Also in partnership with industry, the goal by the year 2005 is to demonstrate technologies capable of economically producing ethanol from energy crops, such as switchgrass. Since energy crop technologies complement various end use applications, funds are requested by both Biomass/Biofuels Energy Systems–Transportation (\$5,500,000) and Biomass/Biofuels Energy Systems–Power Systems (\$3,100,000). Under Biofuels Energy Systems the intent is to develop and demonstrate technologies capable of producing ethanol at a cost of \$0.72 per gallon by the year 2010. To accomplish the program’s cost goals and proceed beyond the first demonstration facilities, research, development and demonstration activities are conducted in accordance with integrated biomass feedstock and conversion systems. Energy cropping systems using the best varieties and management practices must be developed through breeding and reliable field testing in the different growing regions in the United States across a wide range of sites and

conditions. Once developed, these cropping systems will be capable of providing reliable biomass feedstock supplies for the production of fuels, chemicals, and electricity. Recent success with integrated crop systems in the Northwest obtained biomass production levels of over five times that of natural systems and serves as a model to develop the technology nationwide. Clones developed through DOE-funded research have led to the commercial deployment of 60,000 acres in the Northwest.

Specific areas within the conversion process (conversion of feedstocks to products such as ethanol) have been identified which offer the most significant opportunities for efficiency improvements and cost reductions. These areas include improvements in enzyme production and efficiency (so that less enzyme is needed), pretreatment methods that prepare the biomass for conversion to ethanol, and fermentation organisms to convert the range of sugars that can be found in the differing types of biomass materials. The program will also evaluate potential cost reductions based on possible co-products, including electricity and industrial chemicals. Biomass/Biofuels Energy Systems-Transportation and Biomass/Biofuels Energy Systems-Power Systems are conducting analyses of biomass resource availability in a coordinated fashion. Most of the research and development activities for feedstock and conversion improvements are conducted through the Department's national laboratories, using in-house capabilities, subcontracted researchers and facilities at universities, other government agencies such as the United States Department of Agriculture, and industrial scientists with the best expertise and experience.

The Biofuels Energy Systems-Transportation program is also exploring opportunities to produce renewable fuels for heavy vehicle use by supporting biodiesel production activities. These activities include research to lower the costs of biodiesel and the testing and development of new fuel formulations for heavy vehicle use. Niche opportunities for biodiesel are available in environmentally sensitive areas, such as underground mining, marine, and fragile ecosystems (e.g., National Parks). Diethyl ether (DEE) made from ethanol is a fuel that will also be evaluated for its application to heavy vehicle use. DEE's high cetane number and other fuel properties make it particularly attractive for heavy vehicle application.

The Regional Biomass Energy Program (RBEP), funded as a part of this Biofuels Energy Systems-Transportation program (with an additional \$1,000,000 being requested by the Biomass Power program in the Office of Power Technologies) plays a significant role in technology deployment. RBEP, through its local and regional contacts, transfers current and reliable information on biomass development activities to potential users. This includes economic and technical information, as well as State and local regulatory, environmental, and market considerations for the production of fuels, chemicals, and electricity. Existing organizations, such as the Coalition of Northeastern Governors, Council of Great Lakes Governors, the DOE Atlanta Regional Support Office, the DOE Seattle Regional Support Office, and the DOE Denver Regional Support Office, serve as RBEP hosts and contacts for their respective regions in the United States.

Strategic Approach

During the 20th century, our nation's economy has depended heavily on imported fossil fuels. Biomass — a renewable alternative — represents a tremendous, untapped, domestic resource for our energy future. By investing in a bioenergy industry today, we can cultivate and harness these renewable resources to fuel our cars, power our homes and industries, and supply our chemical needs in the 21st century. The Department of Energy, along with other federal agencies and private partners, is launching

a national partnership to develop an integrated industry to produce power, fuels, and chemicals from crops, trees, and wastes. By making a "ton of biomass" a viable market competitor to a barrel of oil or a railroad car of coal, this initiative will help grow the U.S. economy, strengthen U.S. energy security, protect the environment, and revitalize rural America. This effort will integrate the work from existing DOE R&D in transportation biofuels, biomass power and the Forest Products and Agriculture Industries of the Future programs to enable technologies that produce different combinations of fuels, power, chemicals and other products from different feedstocks in different areas of the country. It is only through the integration of these efforts that biomass will be an effective competitor to imported fossil fuels.

A strong Biofuels program is consistent with the recommendations by many internal and external studies that have examined various DOE programs. For example, the PCAST report, and reports on actions to reduce global warming omissions, recommend increased funding for biofuels on the basis that biofuels constitute the most promising and reasonable supply-side alternative for reducing carbon emissions in the transportation sector.

The Comprehensive National Energy Strategy also encourages the deployment and development of advanced biofuels technologies to diversify our energy options, promote domestic rural economic development, and reduce carbon emissions in the transportation sector. A strategy cited DOE's Strategic Plan states, "In FY 2000, startup of a demonstration facility that converts low-cost waste biomass into ethanol at a production cost of \$1.13 per gallon (1996 dollars) compared to \$1.22 per gallon in 1996." The Office of Transportation Technologies' Strategic Plan identifies a biofuels milestone in 2001 as "pilot demonstration (of ethanol production) with wastes." The Biofuels Energy Systems-Transportation goals and strategies are consistent with the various levels of DOE strategic planning.

Program Benefits

Metrics	FY 2000	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.00	0.36	1.00
Energy Savings (\$ Billions)	0.00	0.00	0.07
Carbon Displaced (MMTCE)	0.00	6.70	19.00
Oil Displacement (million barrels per day)	0.00	0.20	0.50

Performance Measures

FY 2000 Performance Measures

- # Establish economic feasibility of enzymatic conversion of cellulose to ethanol (on site *Trichoderma reesei* production) at the bench scale.
- # Select partner to demonstrate enzymatic conversion of cellulose to ethanol as an add-on to corn-to-ethanol facility.
- # Establish partnership with equipment manufacturers and other groups for R&D of harvesting, handling, and storage alternatives for switchgrass.

Energy Supply/
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Biomass/Biofuels Energy Systems-Transportation

FY 2000 Congressional Budget

- # Ethanol production cost competitive in the oxygenate market for acid hydrolysis plants with shared infrastructure (e.g., colocated with biomass power plants) and with access to biomass feedstocks at less than \$5 per dry ton.

FY 2001 - 2006 Performance Measures

- # Select enzyme manufacturing partner to develop advanced cellulase enzyme system. (2001)
- # In partnership with USDA, complete development of integrated equilibrium economics model for energy crops. (2002)
- # Ethanol production cost competitive in the oxygenate market for acid hydrolysis plants with shared infrastructure (e.g., colocated with biomass power plants) and with access to biomass feedstocks at less than \$10 per dry ton. (2003)
- # Demonstrate 3-fold improvement (from 1998 base) of cellulase enzyme activity. (2004)
- # Ethanol production cost competitive in the oxygenate market for enzyme hydrolysis plants with shared infrastructure (e.g., colocated with biomass power plants or corn ethanol plants) and with access to biomass feedstocks at less than \$15 per dry ton. (2006)
- # Begin development of enzymatic conversion technologies with appropriate industry partners. (2002)
- # In partnership with USDA, complete development of integrated equilibrium economics model for energy crops. (2002)
- # Begin commercial demonstration of softwoods to ethanol and electricity. (2003)
- # Complete pilot testing of countercurrent pretreatment reactor with industry. (2003)
- # Demonstrate 3-fold improvement (from 1998 base) of cellulase enzyme activity. (2004)
- # Conduct pilot testing with ethanol partner for energy crop conversion. (2004)
- # Begin small commercial scale demonstration of enzymatic process in collaboration with a corn-ethanol producer. (2005)
- # Demonstrate first-of-a-kind switchgrass conversion to ethanol at a production plant. (2005)
- # Demonstrate improved enzymatic hydrolysis technology at the pilot scale. (2006)

Significant Accomplishments and Program Shifts

Pre-FY 1998 Accomplishments

- # Received the prestigious R&D 100 award for developing *Zymomonas mobilis*, a fermentation organism capable of converting 30% of available sugars to ethanol. (1995)
- # Successfully operated the process development unit in an integrated continuous mode with an industry partner at the National Renewable Energy Laboratory's Alternative Fuels User Facility. (1996)

- # Developed hybrid poplar clones in the feedstock development activity which have been planted commercially by industry on over 75,000 acres in the Pacific Northwest. (1997)
- # Established a partnership with BC International for the first domestic biomass ethanol production facility in Louisiana. (1997)

FY 1998 Accomplishments

- # Completed bench-scale development and formed partnership for converting softwoods to ethanol using dilute acid hydrolysis.
- # Expanded switchgrass breeding activities and initiated a 20-acre research test to validate the yield and cost of switchgrass production.
- # Collaborated with biomass power program to initiate a large scale switchgrass planting activity.
- # Completed bench- and pilot-scale testing of converting sugar cane bagasse to ethanol.
- # Completed separate competitive solicitations to develop advanced enzymes, to produce the next generation fermentation organisms, and to conduct bioethanol feasibility studies at corn-to-ethanol plants.

FY 1999 Planned Accomplishments

- # Complete at least one feasibility study of corn-add-on facility for the conversion of cellulosic feedstocks.
- # Establish partnership with timber industry, United States Forest Service, and local communities to evaluate environmental and social effects of watershed forest management to suppress forest fires through production of ethanol and electricity using forest thinning.
- # Complete bench scale testing of rice straw conversion to ethanol.

FY 2000 Planned Accomplishments

- # Successfully demonstrate conversion of agricultural waste to ethanol at a small commercial scale using a genetically engineered organism.
- # Successfully demonstrated concentrated acid conversion of rice straw at a small commercial scale, integrated with byproduct recovery.
- # Complete engineering feasibility of softwood feedstocks representative of Alaska, in collaboration with industry partners.
- # Release new improved hybrid poplar clones for public use.

FY 2001 - 2004 Planned Accomplishments

- # Complete pilot scale R&D of rice straw conversion to ethanol and electricity. (2001)
- # Start up municipal solid waste-to-ethanol plant. (2001)
- # Complete pilot scale R&D of softwood conversion to ethanol and electricity. (2002)

- # Complete pilot scale testing of conversion technologies in cooperation with corn ethanol industry. (2003)
- # Complete pilot testing of advanced fermentation organism with ethanol partner for energy crop conversion. (2004)

Program Completion

The program is anticipated to be completed in 2015, depending on the state of adoption of the technology. Modest support for research and development to further increase process efficiencies and reduce costs of producing biofuels from energy crops for transportation purposes may be required beyond this time frame.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	\$ Change	% Change
Ethanol Production	25,027	35,950	37,441	1,491	4.1%
Biodiesel Production	800	750	1,000	250	33.3%
Feedstock Production	2,500	2,800	5,500	2,700	96.4%
Regional Biomass Energy Program	2,000	2,250	3,500	1,250	55.6%
Integrated Bioenergy Research and Development . . .	0	0	6,000	6,000	>999.9%
Total, Biomass/Biofuels Energy Systems - Transportation	30,327	41,750	53,441	11,691	28.0%

Detailed Program Justification

(dollars in thousands)

FY1998	FY 1999	FY 2000
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Ethanol Production

- # **Advanced Fermentation Organisms R&D** - Research and development of advanced fermentation organisms to improve conversion process efficiency, including the development of *Zymomonas mobilis* with enhanced capabilities (FY 1998) and the development of organisms with increased stability, robustness, and ability to ferment mixed sugars from waste

feedstocks and the model energy crop switchgrass (FY 1999) to improve process efficiency and lower the cost of ethanol production from biomass.

(dollars in thousands)

FY1998	FY 1999	FY 2000
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- # Testing of these strains at pilot scale and small scale commercial facilities will be completed to demonstrate reliable performance of these first generation organisms. Research and development of advanced (second generation) organisms, such as *Lactobacillus*, that can ferment additional biomass feedstocks with greater efficiencies will provide further cost reductions and the potential for expanding biomass ethanol applications. This funding level is considered appropriate based on extensive experience with laboratory and pilot scale operations and personnel costs. 1,960 2,200 3,000
- # **Advanced Cellulase R&D** - Analyses indicate that the production of ethanol, using enzymes for the breakdown of biomass materials to sugars for fermentation, is limited to a great degree by the high cost of enzymes. Research and development partnerships with enzyme producers will be established to provide more productive, lower cost cellulase systems. Collaborations with enzyme and biomass ethanol producers will be developed to accelerate the use of commercially-available cellulase systems. The funding level was determined based on cellulase colloquys with industrial experts and potential cost-sharing and program reviews.. . . . 2,455 4,547 5,500
- # **Pretreatment R&D** - Physical and/or chemical pretreatment of biomass facilitates enzyme and fermentation reactions, thereby improving process efficiency and lowering costs. An advanced pretreatment reactor, the countercurrent pretreatment reactor, was designed, fabricated and delivered to the National Renewable Energy Laboratory process development unit in FY 1998. In FY 1999, focus is on installation of the reactor system. In addition, bench scale testing of more cost-effective pretreatment technology options, with assessment of for softwoods feedstocks potential chemical co-products, will improve process economics of producing ethanol from forest thinnings.

(dollars in thousands)

FY1998	FY 1999	FY 2000
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# In FY 2000, shakedown and testing of the countercurrent reactor system will be completed and an industrial partnership will be established for commercial demonstration of pretreatment technology. Funding level is considered appropriate based on experience with operations and personnel costs and cost-sharing by industry partner.	1,960	2,800	5,508
# Consortium for Plant Biotechnology Research - Seventeen grants were competitively awarded to University members in FY 1998 and fifteen awards were made in FY 1999 for basic research. The 50:50 cost-shared, long term R&D projects with The Consortium for Plant Biotechnology Research, Inc., (CPBR) for peer-reviewed, basic university research will not be continued in order to focus on more applied research activities that support program goals and objectives.	2,455	1,250	0
# Integrated Process Development - In FY 1999, integrated bench-scale studies will evaluate the overall process and performance of softwood thinnings from private and public forests, including National Forests, in cooperation with industrial partners. Technologies for the coproduction of ethanol and high value products will be researched and developed by the Michigan Biotechnology Institute (MBI). DOE will provide \$3,000,000 to MBI, in accordance with Congressional guidance.			
# Integrated bench-scale and pilot-scale testing of the overall process (handling, pretreatment, fermentation) will evaluate performance, efficiency, and costs for conversion of agricultural waste feedstocks, such as rice straw. Softwood feedstocks, such as thinnings from private and public forests, will be tested at the NREL Biofuels User Facility/Process Development Unit, in support of commercial partners considering the production of ethanol and integrated co-products. Analytical studies will assess the process economic goals. The development of coproducts and by-product utilization will continue to provide a means for expanded technology demonstrations and lower ethanol production costs. Funding is considered appropriate based on standard cost-estimating practices implemented and validated at the laboratory (operations and personnel costs). . .	8,265	11,500	11,500

Energy Supply/
Solar and Renewable Resources Technologies/
Biomass/Biofuels Energy Systems-Transportation

FY 2000 Congressional Budget

(dollars in thousands)

FY1998	FY 1999	FY 2000
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# Feasibility Studies - Several cost shared feasibility studies were completed in FY 1998. Feasibility studies are an integral part of assessing the technical and economic viability of individual ethanol production facilities. Therefore they will be continued under the activity Cellulose-to-Ethanol Production Facilities, in FY 1999 and FY 2000.	841	0	0
# Cellulose-to-Ethanol Production Facilities - Laying the groundwork for a broad-based cellulosic biomass-to-ethanol industry, cost-shared partnerships to design and construct ethanol production facilities are being developed. In FY 1998, an additional commitment to design and construct biomass waste-to-ethanol facilities was obtained. DOE's commitment for the BC International (BCI) project, initiated in FY 1997, was \$4,000,000, with BCI cost-share of \$27,600,000, or 87%. An additional \$750,000 was included under Biomass Power for the Gridley, California project. A minimum 50% cost share was required from any partner entering into an agreement.			
# In FY 1999, DOE's commitment with BCI for the Jennings, Louisiana plant will be completed, in accordance with Congressional guidance. An additional commitment with an industrial partner will be established, leading to the design and construction of an ethanol facility in Rio Linda, California. DOE share for the Rio Linda facility is \$4,000,000, in accordance with Congressional guidance. An additional commitment with industry partners will be established, leading to the design and construction of commercial demonstration facilities in targeted areas of California and Alaska.			
# In FY 2000, support of commitments established in fiscal years 1998 and 1999 will continue. Softwood pilot scale testing will accelerate deployment through continued support of integrated bench-scale enzymatic hydrolysis testing. Partnerships will be developed to demonstrate enzymatic conversion of cellulosic biomass to ethanol in support of the corn ethanol industry. Partnerships will also be established to demonstrate coproduction of ethanol at coal-fired power stations. Funding level is considered appropriate, providing minimum cost-share in some cases (20%) by DOE and are based on prior experience with these types of partnerships.	7,091	13,653	11,933
Total, Ethanol Production.	25,027	35,950	37,441

(dollars in thousands)

FY1998	FY 1999	FY 2000
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Biodiesel Production

# Biodiesel Production Technologies - Based on a technoeconomic assessment, research and development will improve biodiesel process technology, using waste grease streams to lower production costs. In addition, improved oilseed production research and development will be conducted to lower biodiesel production costs. Working with industry, activities to facilitate market penetration will continue that will lead to increased biodiesel production and use. Funding level is considered appropriate and depends on cost-sharing to be successful. Research and development based on work involved and personnel requirements.	600	750	1,000
# Waste Oil Assessment - An evaluation of the quantity, availability, and potential of waste oils as a transportation fuel was completed.	200	0	0
Total, Biodiesel Production.	800	750	1,000

Feedstock Production

# Biomass Feedstock Development Centers - Research will be conducted to develop economically viable model energy crops at integrated biomass feedstock development centers in the Pacific Northwest (poplars), Southeast (switchgrass), Midwest/Plains States (switchgrass and poplars) and Northeast/Lake States (willow). At these centers, breeding to select for higher yields and other desirable traits is linked closely with studies on management, physiology, growth-limiting factors, and advanced biotechnology. Field studies to evaluate nutrient effects on carbon sequestration and storage will be added to provide additional vital information on energy crops. Funding level determined from prior experience with work involved and makes use of experts at universities and U.S. Department of Agriculture over four regions of the U.S.	1,600	1,600	4,000
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(dollars in thousands)

FY1998	FY 1999	FY 2000
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Environmental Effects of Energy Crop Deployment -

Research to evaluate the effects of large scale deployment of energy crops on the environment, such as water and soil quality, chemical fates, and biodiversity will provide credible data that can be used to guide deployment in a manner that ensures energy and environmental benefits. Funding level is considered appropriate based on the level of effort which makes use of existing field sites.

400 225 225

Energy Crop Seedling/Planting Stock Selection Research -

Advanced biotechnology and other methods will develop techniques that can be used to select energy crop seedlings or other planting stocks that are less susceptible to disease and/or pests, reducing the risk of mortality and increasing technical/economic viability. Desirable genotypes of switchgrass will be selected, propagated, and transferred to greenhouse/field tests to verify the selection process. Funding level is based on level of effort for this university project.

100 100 100

Large Scale Woody Crop Plantation Research -

Research will be conducted to develop and evaluate management techniques to overcome the water use efficiency constraints in the Southeast. Technical assistance and cost sharing will be provided for existing large scale plantings in the Midwest/North Central region to obtain performance and cost data. Funding level was determined from level of effort needed to provide technical assistance by a laboratory expert for these large scale plantings and low level cost share.

150 125 125

Switchgrass Variety Testing and Scale-up Research -

Switchgrass variety field tests are being conducted in the major growing regions of the U.S. Field trials established at five USDA National Plant Materials Testing Centers will evaluate newly developed switchgrass lines. Cost-shared 100-300 acre scale-up plantings of switchgrass will be evaluated to provide yield, operational issues, and cost data. Field tests and scale-up data will be collected and evaluated and field trials near waste-to-ethanol facilities/sites will be established. Funding level is considered appropriate based on level of effort, work scope and use of university and U.S. Department of Agriculture expertise and facilities.

200 500 500

Energy Supply/
Solar and Renewable Resources Technologies/
Biomass/Biofuels Energy Systems-Transportation

FY 2000 Congressional Budget

(dollars in thousands)

FY1998	FY 1999	FY 2000
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# Feedstock Composition and Multi Product Use - Altering plant composition to improve conversion efficiencies will provide potential benefits and cost reductions in the production of fuels, chemicals and electricity. The tailoring of plants so that all components of the plant can effectively be used to produce multiple products will provide potential cost reductions and broader opportunities for adaptation of feedstock production systems. Plant biotechnology research will be initiated, based on co-product potentials and strategies identified in FY 1999. Funding level is appropriate considering the work scope involved.	0	100	200
# Mechanization Research - Mechanization systems for energy crops, to lower harvesting/handling costs, will address a major obstacle to the widespread use of energy crops. Cost-shared opportunities for switchgrass handling and storage, specifically as a means of improving the ethanol production costs, will be explored. Handling and storage systems for the use of agricultural residues to produce ethanol will be evaluated to improve costs and process efficiencies. Funding level was determined by work scope and requires cost sharing.	50	150	350
Total, Feedstock Production.	2,500	2,800	5,500

Regional Biomass Energy Program

# Regional Biomass Resource Activities - Regionally-focused activities with State and local governments, together with industry will further develop the capability to produce and use biomass resources for multiple products. Funding level is determined based on extensive prior experience with this activity and cost share requirements.	1,650	1,650	2,000
# Biofuels Production Resource Activities - Using the regional program infrastructure, support will be provided for cost-shared site studies for biofuels production facilities, including resource assessments and analyses of local, State, and regional nontechnical issues.			
# The potential of biodiesel will be improved by testing new biodiesel fuel formulations to enhance fuel performance of high			

Energy Supply/
Solar and Renewable Resources Technologies/
Biomass/Biofuels Energy Systems-Transportation

FY 2000 Congressional Budget

(dollars in thousands)

	FY1998	FY 1999	FY 2000
efficiency engines, in collaboration with the Office of Heavy Vehicle Technologies in the Office of Transportation Technologies, USDA, and the National Biodiesel Board. Funding level is considered appropriate based on work scope and prior experience in this activity plus cost share.	350	600	1,500
Total, Regional Biomass Energy Program.	2,000	2,250	3,500

Integrated Bioenergy Technology Research and Development

# Coordination and integration of biomass related activities are critical to the future economic viability of biomass based products such as fuels, chemicals, and electricity. Increased collaboration among industry partners, stakeholders, DOE programs, and DOE laboratories is resulting in converging opinions on an industry R&D agenda and will lay the foundation for accelerating the development and use of diverse bioenergy feedstocks and enhance their capabilities to produce a variety of products responsive to market demands, thereby increasing the prospects for a broad-based bioenergy industry in the U.S. A total systems analysis will be initiated, with industry participation, to support the goal of optimizing the integration of bioenergy feedstocks, equipment, and end products for biomass energy systems. High priority technologies and processes will be identified, based on this and previous analyses, and provide a road map of future bioenergy system R&D needs. Common linkages and synergies will be identified and applied between fermentation, gasification, and other biomass-related activities currently funded by the Department. Existing and planned technology development projects supported by the Department's Biofuels, Biopower, and Industrial Programs will be re-evaluated and enhanced to allow for integrated processing of diverse feedstocks and options for a variety of products. The funding level is based on previous experience with similar projects, anticipated laboratory in-house costs, data gathered from stakeholders and the level of effort required to accomplish program goals.	0	0	6,000
Total, Biofuels Energy Systems.	12,391	19,453	27,933

Explanation of Funding Changes from FY 1999 to FY 2000

FY 2000 vs. FY 1999 (\$000)

Ethanol Production

# Conduct advanced fermentation organism R&D at the pilot and small commercial scale in partnership with industry.	+800
# Increase support for advanced cellulase research, including collaboration with enzyme and ethanol producers to accelerate the use of commercially-available cellulase systems.	+953
# Increase support for shakedown, testing, and commercial demonstration of the countercurrent pretreatment reactor that will substantially lower biomass conversion costs for ethanol and other products.	+2,708
# Discontinue support for The Consortium for Plant Biotechnology Research activities, which are geared to basic research and no longer meet program goals. . .	-1,250
# Decrease support for industrial partnerships in order to focus on the development of the countercurrent pretreatment reactor.	-1,720
Total, Ethanol Production.	+1,491

Biodiesel Production

# Conduct research and development to improve biodiesel technology and lower costs of production.	+250
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Feedstock Production

# Increase is to fully support feedstock development centers, scale-up research, and mechanization research for the production of fuels and coproducts, in collaboration with Biopower Energy Systems.	+2,700
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Regional Biomass Energy Program

# Increase to support the conduct cost shared site studies for biofuels production facilities and regionally focused activities that will include fuel formulation testing to improve biodiesel performance.	+1,250
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Integrated Bioenergy Technology Research and Development

# Facilitate development of the bioenergy industry vision and roadmap and fund highly leveraged R&D for highest priority technologies.	+6,000
Total Funding Change, Biofuels Energy Systems.	+11,691

Energy Supply/
Solar and Renewable Resources Technologies/
Biomass/Biofuels Energy Systems-Transportation

FY 2000 Congressional Budget

Biomass/Biofuels Energy Systems - Power Systems

Mission Supporting Goals and Objectives

Program Mission

The Biomass Power Systems Program mission is to integrate sustainable biomass feedstock production with efficient biomass power generation to enable biopower to be a major cost-competitive contributor to power supplies in both domestic and international energy markets.

Program Goals and Objectives

By 2004, in collaboration with USDA, power producers, manufacturers, farmers, and foresters, the Biomass Program will have engaged in research and development activities to increase the viability of clean, efficient, biomass technologies for a variety of markets to achieve an additional 3,000MW of new biomass power capacity in the U.S., increasing the total to 10,000MW of domestic capacity. The program will benefit the American taxpayer by: helping to revitalize rural economies by providing jobs linked to renewable power production and co-products such as fuel, fiber, and feed; diverting biomass residues from the waste stream; and improving the environment in the near term through reduction in greenhouse gas emissions.

Significance of the Biomass Power Systems Program Goal to the Strategic Goal. Biomass Power Systems will be a major contributor toward meeting or exceeding the Solar and Renewable goal of doubling the renewable energy output by 2010. Biomass Power contributes to several of the objectives of the Energy Resources Strategic Goal in the DOE Strategic Plan.

Strategic Approach

Biomass is a local power solution with global benefits. The goal of the Biomass Power Systems Program is to develop and validate clean, efficient, renewable, biomass-based electricity generation technologies and operational systems with sustainable biomass supplies. We have three major energy technology thrust areas: 1) co-firing biomass with fossil fuels such as coal and natural gas, 2) small modular biomass power system and 3) advanced biomass gasification. We have begun a concentrated effort to demonstrate near-term benefits of modifying coal plants to allow 3% to 15 % of the fuel to come from biomass resources such as wood residues and from energy crops such as fast-growing willow trees. The Small Modular Systems Development Initiative will serve to bring viable biomass technologies into the global marketplace in the near term. Advanced gasification technologies are beginning to make a mark today, but will play a strong role in the longer-term. In addition, cost-competitive feedstock development and resource assessment are indispensable components of an integrated national biomass strategy. Increasing yield and decreasing production costs are critical to the penetration of biomass into the marketplace.

During the 20th century, our nation's economy has depended heavily on imported fossil fuels. Biomass—a renewable alternative—represents a tremendous, untapped, domestic resource for our energy future.

By investing in a bioenergy industry today, we can cultivate and harness these renewable resources to fuel our cars, power our homes and industries, and supply our chemical needs in the 21st century. The Department of Energy, along with other federal agencies and private partners, is launching a national partnership to develop an integrated industry to produce power, fuels, and chemicals from crops, trees, and wastes. By making a “ton of biomass” a viable market competitor to a barrel of oil or a railroad car of coal, this initiative will help grow the U.S. economy, strengthen U.S. energy security, protect the environment, and revitalize rural America. This effort will integrate the work from existing DOE R&D in transportation biofuels, biomass power and the Forest Products and Agriculture Industries of the Future programs to enable technologies that produce different combinations of fuels, power, chemicals and other products from different feedstocks in different areas of the country. It is only through the integration of these efforts that biomass will be an effective competitor to imported fossil fuels.

The program is expanding its focus to include a full complement of efficient biomass technologies, size ranges, and feedstocks (agricultural residues, wood residues, energy crops, etc.). The program is working to balance the research and demonstration efforts to most effectively advance the technology. Toward this goal, we are asking for increased support for thermochemical conversion research over the five-year period as we maintain support for large demonstration projects. We think that additional simulations and performance modeling in the laboratory will allow us to save time and money during field demonstration projects. To take advantage of additional feedstocks, we are beginning the Cooperative Agricultural Residues to Energy Initiative aimed at pairing animal producers, local energy producers (such as electric cooperatives), and state health, environmental and energy officials to develop projects which use animal manure or litter to produce power, making productive use of an environmental hazard. Increased focus on feedstock production, processing and handling is also necessary to advance biomass energy technology.

We remain committed to forging partnerships with other Federal agencies, communities, power generators, manufacturers, farmers and foresters to fully demonstrate sustainability of clean, renewable, biomass power. Although several of the technologies are nearing commercial viability, the Federal dollars help to reduce the risk that pioneer developers and power producers experience when initially using a new technology. Without the encouragement and support of the Biomass Power Systems Program, it’s unlikely that clean and efficient biomass power would be produced in significant quantities.

Program Benefits

Metrics	FY 2000	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.03	0.42	0.53
Energy Savings (\$ Billions)	0.00	-0.15	-0.21
Carbon Displaced (MMTCE)	0.62	10.49	12.95

The primary energy displaced in 2010 will be enough to power 5.2 million U.S. homes, and 9.0 million homes in 2020.

The carbon reductions achieved are equivalent to removing 2.5 million vehicles from U.S. highways by 2010, and 11 million vehicles by 2020 (8% of today's total U.S. vehicles).

Performance Measures

FY 2000 Performance Measures

- # Develop successful quantitative modeling tools to assist industry increase use of combustion and cofiring of biomass fuels and coal.
- # The Biomass Power Systems Program will successfully complete engineering, installation and commissioning of the catalytic gas conditioning and compression system at Vermont's biomass gasification facility through partnerships with the private sector. Long-term operational testing of the gasifier will provide the forest products industry with performance data for implementation of these systems in that sector.
- # Successful completion of the NIPSCO Bailly Cofiring demonstration will facilitate diffusion of biomass and coal cofiring throughout the industry.
- # Assist the private sector in the selection of high-yield hybrid poplar clones and the production of cuttings (millions) for commercial planting.

FY 2001 - 2006 Performance Measures

- # Complete successful demonstration of the benefits of integrated gasification combined cycle in Vermont which will have applications to the Forest Products and other industries as they implement capital replacement projects with advanced gasification technology power houses.
- # Complete demonstration of prototype units for three high efficiency and low emissions small biomass gasification (or combustion) concepts integrated with modular power generating systems. These systems will be ready for diffusion and dissemination at national and international levels.
- # Develop and demonstrate high yield short rotation plants and grasses for biomass power uses. For instance, successful high yield varieties of willows, poplars, and switchgrasses. In excess of 5,000 new acres of different high-yielding varieties will be planted by the private sector and used in power applications.
- # Generate 2 GWe (0.05 Quads/y) from biomass and coal cofiring offsetting 4 million metric tons of fossil carbon per year.

Significant Accomplishments and Program Shifts

Pre-FY 1998 Accomplishments

- # Conducted critical and pioneering applied research, pilot testing, and feasibility studies in the areas of biomass combustion and biomass gasification, which provided the foundation for advanced and improved technology development. Examples include:
 - ▶ Successfully reduced alkali metals in pyrolysis oils using fundamental understanding of alkali behavior gained from basic laboratory research and field measurements.
 - ▶ Developed industry guidelines for direct combustion of high alkali biomass feedstocks.

- ▶ Successfully operated a small (200kW) gas turbine with biomass synthesis gas.
- ▶ Pioneering studies on overall emissions of biomass-based power systems that demonstrated “carbon closure.”

FY 1998 Accomplishments

- # Successfully demonstrated sustained operation of the Battelle/FERCO advanced biomass gasifier in Burlington, Vermont, at the McNeil Biomass Power Station.
- # Initiate co-firing demonstrations with modifications started at two power stations.
- # Completed feasibility studies for ten diverse small modular systems.

FY 1999 Planned Accomplishments

- # Complete design and site preparation to begin gasifier construction in Minnesota for the MnVAP Biomass Power for Rural Development project.
- # Complete design of power plants modifications for co-firing of Biomass with coal activities.
- # Solicited and selected small modular systems for testing and demonstrations.
- # Development of a technology roadmap for bioenergy technologies.

FY 2000 Planned Accomplishments

- # Successfully demonstrate sustained operation of the total Vermont biomass system (gasifier, gas clean up, and advanced biogas turbine).
- # Complete the power plant retrofit for co-firing switchgrass with coal in Iowa for the Chariton Valley Biomass Power for Rural Development project.
- # Complete three projects which will be co-firing with biomass on a regular basis.
- # Complete testing of two to three small modular systems.
- # Complete resource database for biomass crops and residues.
- # Complete laboratory testing of a fuel cell and 2 types of engines coupled with the lab-scale biomass gasifier.

FY 2001 - 2006 Planned Accomplishments

- # Complete demonstration of two to three of the most promising Small Modular Systems Initiative projects.
- # Complete the development of 2 high-yield woody biomass crop clones and release them to nurseries.
- # Complete the Small Modular Systems Initiative with two to three small-scale biomass systems poised for rapid commercialization by the private sector.
- # Complete all three Biomass Power for Rural Development projects with more than 100MW of new biomass power generating capacity.
- # Complete development of 3 high-yield willow clones which increase yields by at least 20%.

- # Complete the Co-firing Initiative with new facilities that were in the partnership. Facilities are co-firing biomass on a regular basis.
- # Operate five or more successful demonstration projects with animal manure as a fuel for electricity production as part of the Cooperative Agricultural Residues to Energy Initiative.

Program Completion

Completion of the program is anticipated to be in 2008, depending on the state of adoption of the technology. Modest support for research and development to further increase efficiency and decrease emissions from biomass power plants may be important beyond this time frame.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	\$ Change	% Change
Thermochemical Conversion	1,500	1,550	2,700	+1,150	+74.2%
Systems Development	21,017	26,350	32,150	+5,800	+22.0%
ATS/Biomass for Cogeneration	2,564	0	0	0	0.0%
Feedstock Development	1,723	2,300	3,100	+800	+34.8%
Regional Biomass Energy Program	985	1,250	1,000	-250	-20.0%
Total, Biomass/Biofuels Energy Systems - Power Systems	27,789	31,450	38,950	+7,500	+23.8%

Detailed Program Justification

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Thermochemical Conversion

- # **System Integration Research** - This funding supports research on gas treatment/cleanup options to power highly

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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efficient, environmentally-benign small power systems which are needed in national and domestic markets. It also supports various demonstration efforts (e.g., Vermont gasifier) identified as critical to industry. The focus of this phase is the development of performance parameters for integrated gasification power producing systems. This funding level is based on sustaining a multi-year program as it moves into the testing phase at NREL Thermochemical User Facility.

Thermochemical conversion research is the foundation of the Biomass Power Program and plays a key role in providing data for critical planning and decision-making processes. Efficient and cost-effective analysis produced in a laboratory setting enables the program to make sound decisions on technology prior to field demonstration and validation.

880 900 1,400

Co-firing/Ash Deposition - This effort conducts research to minimize problems related to the high alkali metal contents of many biomass fuels which can lead to fouling, slagging, and corrosion in conventional biomass furnaces and boilers, and in pulverized fuel utility boilers cofiring biomass and coal. Funding levels increase is to incorporate results from research on formation, evolution and reaction of chemical compounds in gasification and combustion environments into databases and models. This effort conducts research to minimize problems related to the high alkali metal contents of many biomass fuels which can lead to fouling, slagging, and corrosion in conventional biomass furnaces and boilers, and in pulverized fuel utility boilers cofiring biomass and coal. These research results are directly linked to the Department's performance measure for co-firing.

350 350 500

Systems Analysis and Modeling - The impact of a restructuring environment on technology development needs to be assessed. The level of NOx emissions will be modeled and verified. This activity leads to maximizing pollution reduction and minimizing the need for incentives.

270 300 600

(dollars in thousands)

	FY 1998	FY 1999	FY 2000
# Capital Equipment - Gas cleaning integration modules, conversion devices, and analytical equipment will be purchased in support of systems integration research. This equipment is essential to the laboratory as accuracy and precision in research are afforded by having up-to-date equipment.	0	0	200
Total, Thermochemical Conversion.	1,500	1,550	2,700

Systems Development

# Hawaii Gasification Project completion and close out.	600	0	0
# The Vermont Gasifier Project will demonstrate a pilot-scale state-of-the-art gasifier combined with an advanced turbine, producing approximately 8-12MW of electricity from wood. Gasification vessel completed and tested (FY 1998). A hot-gas clean up unit will be installed and the integrated combined cycle gasification system will be operated for 1,000 hours at double the efficiency of direct-fired biomass units (FY 2000).	1,550	3,000	5,500
# The three (3) Biomass Power for Rural Development Projects constitute a Presidential Initiative which began in 1996 that will demonstrate the sustainability of closed-loop energy crops. Specific program objectives include: 1) facilitate the transition from the use of residues to the integrated use of dedicated energy crops and residues; 2) facilitate the expansion of agriculture and its related infrastructure for large-scale energy crop production; and 3) invest in the stewardship of our air, water, and soil resource to produce electricity, goods, and services. It is predicted that by FY 2020, over 10 million acres of energy crops could be in place, supporting over 260,000 U.S. jobs.			
▶ Minnesota Valley Alfalfa Producers - The Minnesota 75 MW gasifier is fueled with alfalfa stems. This project demonstrates a modern biomass power system that will use alfalfa stems for 75 MW of electric power production			

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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and will market the co-product of alfalfa leaves as animal feed. With the completion of the Engineering Design in FY 1999, construction begins in FY 2000. The funding level represents the DOE cost share. Funds are requested for the project to fulfill DOE commitments to the Minnesota Valley Alfalfa Producers (MnVAP) who have signed a power purchase agreement with Northern States Power. The plant is scheduled to open in 2001. Funds will ensure that this date is met.

- ▶ New York Willow Co-firing - The project is demonstrating and quantifying the environmental and economic benefits of cofiring willow and coal in existing power plants with several companies and farmer groups. In the year 2000, up to 600 acres of willow will be planted. Testing of cofiring willow and coal will be conducted and completion of retrofit of two additional coal plants. Funds are required to complete the planned effort in the year 2000. This will enable the timely completion of DOE commitments to the Salix Consortium.
- ▶ Iowa Switchgrass Co-firing - The project is working to establish switchgrass to generate up to 35MW of power by cofiring with coal. In the year 2000, up to 3600 acres of switchgrass will be planted. Retrofitted plant testing will begin. These funds will enable the timely completion of DOE commitments to the Chariton Valley Resource Conservation and Development, Inc.

In the year 2000, these three projects will be in advanced stages of construction, planting, and testing at various facilities which require substantial government cost share. The level of funding is based on the scope of work as described above.

17,367 15,450 17,250

- # **Co-firing Biomass with Coal Initiative** - Extensive testing and trials have shown that biomass can replace up to 15% of the total energy input in existing coal power plants, thus allowing a direct opportunity for carbon mitigation (an estimated 16-24 million metric tons of carbon in 2010), which

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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has been identified as the most cost-effective method of carbon mitigation for utilities. Biomass co-firing also reduces SOx, and potentially, NOx emissions. The DOE initiative will focus on increasing power producer knowledge and confidence through a series of cost-shared co-firing demonstrations in power plants. This initiative will work towards increasing co-firing capacity. In FY 2000, baseline data developed from retrofitting and testing activities at the four established sites will be used to extend the scope of the co-firing initiative to additional sites and to demonstrate sustained operations at selected sites. These research results are directly linked to the Department's performance measure for co-firing.

0 2,500 5,400

Small Modular Systems Development - Initiated 2-3 Phase II development projects and began implementation of projects. These funds will also bring to completion the DOE commitment to the previously awarded ten contracts to the developers of modular systems. Federal support is required to bring to commercial market readiness of biomass-based generation systems that will provide power in the range of electrical generation sizes of 5 kW to 5 MW for domestic and international markets. The development of these systems will be cost-shared. Funding is being provided for feasibility studies, prototype demonstration, and proceeding to full system integration and development of fully mature business strategies. Current global markets projections for these systems are in the range of 40 GW with an annual growth projection 4 percent per year. Increased funding is needed for the testing and demonstration of promising innovative prototype systems.

1,500 2,000 4,000

\$750,000 is being allocated for the Plumas county ethanol project. The program is currently waiting contact by Plumas county. \$1,000,000 is being provided for the demonstration of black liquor gasification; a competitive solicitation process will be conducted with an award being anticipated for the 3rd quarter of FY 2000. \$300,000 for the Vermont methane energy production project has been forwarded to the Vermont

(dollars in thousands)

	FY 1998	FY 1999	FY 2000
State Energy Office. \$100,000 is being provided to evaluate the amount, distribution, and best method of extraction and utilization of methane gas from Sunrise Mountain Landfill in Nevada. Funds have been sent to the Nevada State Energy Office. \$1,250,000 in funding for the Consortium of Plant Biotechnology has been forwarded to this organization.	0	3,400	0
Total, Systems Development.	21,017	26,350	32,150

ATS/Biomass for Cogeneration

# Developed advanced materials/coatings to protect turbine components from oxidation and corrosion.	2,564	0	0
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Feedstock Development

# Feedstock production is critical to the concept of biomass energy systems. Providing economic and environmentally sustainable feedstocks through this effort will help to ensure that investments in conversion systems continue due to the assurance of adequate raw materials supply for biomass facilities. Conduct genetic, physiological, breeding and management techniques research to improve yield of selected grasses.	700	900	900
# Conduct genetic, physiological, breeding and management techniques research to improve yield of willow and other selected short-rotation woody crops.	623	700	1,200
# Develop harvesting, storage, handling and power feeding techniques to improve efficiency and reduce operation cost. . .	0	300	500
# Develop and maintain national feedstock database; assess biomass feedstock availability for specific biomass technologies; and analyze national economic and environmental impacts of feedstock utilization.	400	400	500
Total, Feedstock Production.	1,723	2,300	3,100

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Regional Biomass Energy Program

# The Regional Biomass Energy Program serves as the technology transfer arm of the Biomass Power program and is essential to establishing activities between state government and the private sector.	985	1,250	1,000
Total, Biomass/Biofuels Energy Systems-Power Systems.	27,789	31,450	38,950

Explanation of Funding Changes from FY 1999 to FY 2000

FY 2000 vs. FY 1999 (\$000)

Thermochemical Conversion

# This increase is necessary to continue critical basic research in biomass combustion and gasification characteristics, especially relating to cofiring biomass with coal (a major near-term, low-cost market opportunity) and as applied to integrated gasification power producing systems. Funding level increase to incorporate results from research on formation evolution and reaction of chemical compounds in gasification and combustion environments into databases and models.	+1,150
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Systems Development

# This increase is primarily to support the projects undertaken in the construction and testing of Biomass Power for Rural Development Initiative (\$1,800,000) and the Vermont gasification systems (\$2,500,000), the development of new small-modular biopower systems (\$2,000,000), and includes the support of cost-shared utility scale cofiring demonstrations (\$2,900,000), and the inclusion of earmarks in FY 1999 (-\$3,400,000).	+5,800
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ATS/Biomass for Cogeneration

# No change.	0
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FY 2000 vs. FY 1999 (\$000)

Feedstock Development

# This program will require additional funding for testing of promising new hybrids developed by the program for grasses and Short Rotation Woody Crops specifically for biopower applications.	+800
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Regional Biomass Energy Program

# The decrease in funding is based on the program’s use of the existing infrastructure to deploy biomass technologies through cost-shared grants and activities with State energy offices and Federal and regional organizations.	-250
Total Funding Change, Biomass/Biofuels Energy Systems - Power Systems.	+7,500

Wind Energy Systems

Mission Supporting Goals and Objectives

Program Mission

The mission of the Wind Energy Systems Program is to enable U.S. industry to complete the research, testing, and field verification needed to fully develop advanced wind energy technologies that lead the world in cost-effectiveness and reliability. This mission is an investment in assuring that the United States will fully capitalize on an industrial development opportunity that can create thousands of jobs for the Nation, while increasing domestic and worldwide use of a technology that provides substantial environmental and energy security benefits.

Program Goals and Objectives

The Wind Program has established the following goals as measures of success in accomplishing its mission:

- # Enable U.S. industry to capture 25% of worldwide markets for wind energy by 2005 (sales of over 1,000 MW worth over \$1 billion each year), and
- # Achieve 10,000 MW of wind generating capacity in the United States by 2010 (approximately 1,850 MW on-line in 1998).

The following objectives support achievement of the Program's goals:

- # By 1999, U.S.- based wind turbine certification agent established.
- # By 2002, wind turbines capable of 2 ½ cents/kWh at 15 mph wind sites available from U.S. companies.
- # By 2004, three U.S. companies competing in utility-scale wind turbine markets.

These goals are directly supportive of broader Departmental strategic plans and objectives. The year 2010 capacity goal is a key contribution to realizing the Department's Comprehensive National Energy Strategy goal to achieve 25,000 MW of non-hydroelectric renewable generating capacity by 2010. Without the wind energy contribution of 10,000 MW by 2010 supported by the Wind Program's proposed strategy, this objective is not likely to be achieved. Wind capacity additions provide an energy security benefit since the resource is indigenous and renewable. Wind energy capacity additions make significant contributions responding to environmental objectives such as global warming mitigation and clean air by displacing emissions from fossil-fueled electric generation sources. National economic development objectives are supported by increasing the United States' share of the rapidly growing global market for wind energy systems.

Strategic Approach

During the 1990s, wind energy has been the fastest growing source of energy in the world, increasing at a rate of over 25% per year. Capacity additions in 1998 of over 2,000 MW brought total worldwide installed wind generating capacity to 9,600 MW, with industry sales over \$2 billion. Improvements in wind energy technology have substantially reduced costs and increased reliability over the last decade. As a result, numerous organizations including the Royal Dutch Shell Group, the World Energy Council, and the European Commission have issued statements affirming a strong future for wind energy. The growth in wind energy use will displace airborne emissions, increase energy security, and provide economic growth opportunities throughout the world.

Installation of wind power stations in Europe and developing countries has accounted for most of the recent worldwide capacity increase, with wind turbines supplied primarily by European companies. Wind power development in the United States is beginning to recover from several years of stagnation, with approximately 200 MW added in 1998 and several hundred more forecast for 1999.

However, the future of wind energy in the United States is still highly uncertain as electric power markets deregulate and increase emphasis on low cost of energy production. Continued wind energy technology development is needed to close the cost gap between wind and fossil power generation to assure the viability of wind energy in new competitive power markets, and to allow U.S. technology to compete overseas.

Action must be taken now to help strengthen and expand the U.S. industry, or foreign wind turbine manufacturers are likely to continue capturing a vast majority of the domestic and worldwide wind energy business. The Wind Program's proposed plan is a recovery strategy for the U.S. wind industry that has resulted from numerous meetings with wind industry leaders, electric utility representatives, and the wind energy research community. The strategy, which includes several elements that are already underway in the Wind Program, will bolster the U.S. wind industry through an aggressive program of:

- # Continued applied research to develop cutting edge tools and concepts for wind energy system design efforts, technologies to expand wind energy applications, and strategies to assure cost-effective wind plant operation. This activity provides the fundamental



Wind Energy: A New Cash Crop for the Midwest

This 107 MW wind power plant, located in farmland near Lake Benton, Minnesota, was the world's largest wind generation facility at the time of its completion in 1998 by Enron Wind Corporation. Enron has publicly credited their research partnerships with the Department as essential to the development of the technology making this wind plant possible. Enron's turbine manufacturing subsidiary, Zond Energy Systems Inc. of Tehachapi, California, partnered with the Department under its wind turbine research and field verification programs for the development of the Z-550, Zond's first commercial wind turbine. The technical assistance, testing capabilities, and utility operating experience made possible by the Department's Wind Program were critical to the successful development of Zond's Z-750 turbine used in the Minnesota project. Enron Wind Corp. has several hundred additional megawatts of wind power now under development.

technological underpinnings needed to support the Program's partnerships with industry for advanced technology R&D.

Outcome from core research activities will be carried further through R&D partnerships between government and industry to develop and test innovative components and subsystems for use in new turbine designs, and to attract new participants to the U.S. wind industry. The WindPACT (Wind Partnerships for Advanced Component Technologies) project will continue U.S. technological improvement beyond the next-generation turbines to pave the way for further U.S. technology cost reductions. These reductions, as well as the emergence of new companies in support of the year 2004 objective, will contribute to increasing U.S. market share by 2005, as well as lead to increased domestic deployment of wind energy in support of the 2010 capacity goal. Wind energy expertise and innovative concepts available only from the Wind Energy Systems Program are the key to WindPACT for developing advanced technologies and rapidly cultivating wind energy technology capabilities in companies new to the wind industry.

- # Continued turbine research and field verification. The role of the Turbine Research activity is to provide an opportunity for U.S. industry to apply the technology breakthroughs and design tools from Applied Research in developing advanced technology wind turbines. This role is implemented through close partnerships between the Wind Program's National Laboratories and U.S. companies via competitively awarded, cost-shared subcontracts, typically with 20% to 30% industry share. U.S. wind turbine manufacturers are thinly capitalized and for the most part incapable of financing a major turbine R&D project without government support at the front end. As the project develops, the industry partner assumes more of the cost-sharing. Wind turbines that result from the Next Generation, Near Term, and Small Wind Turbine projects under Turbine Research are critical to fulfilling the Program's cost of energy, market share, and domestic capacity goals.

Field verification is an essential component of the technology development cycle, and also assures performance is proven to investors and financiers. New technologies enabling use of wind energy in hybrid power systems will also benefit from field verification in prototypic remote applications. The financial resources required to complete research and development leading to advanced technology, fully proven wind turbine and hybrid systems have been well beyond what the U.S. wind industry could afford during times of stagnant and uncertain domestic markets. Federal support of such efforts allows U.S. industry to begin positioning for technological leadership now, rather than waiting to establish enough financial capability to independently undertake the R&D needed to, as a minimum, simply maintain competitiveness.

- # Continued priority focus on enhancing U.S. wind turbine certification capabilities and providing U.S. participation in the development of international consensus standards for wind turbine design, testing, and operation. These efforts will ensure that U.S. industry can meet certification requirements of many worldwide market opportunities for wind energy on a level playing field with foreign competition, in support of achieving the year 2005 market share goal.
- # Facilitated transition to restructured electric power markets in the United States through Federally supported analysis activities and partnerships with wind farm operators to characterize power systems integration considerations of wind project performance, and to explore strategies to improve wind energy acceptance by system operators, power marketers and aggregators, and customers. U.S. manufacturers and developers are just beginning to recognize and adjust to the requirements of the

restructured marketplace and have not yet operated projects in which factors such as ancillary services have come in to play. The Wind Program’s planned efforts in this area will lead to expanded opportunities for wind energy in the United States needed to meet the goal of 10,000 MW installed wind capacity by 2010.

Program Benefits

Metric	FY 2000	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.02	0.21	0.61
Energy Savings (\$ Billions)	0.04	0.52	1.76
Carbon Displaced (MMTCE)	0.39	3.52	10.05

By 2000, the annual amount of energy generated from wind in the United States will be equivalent to the annual electricity needs of over 800,000 average households.

Performance Measures

FY 2000 Performance Measures

- # Three prototypes will be installed for field testing under the Small Wind Turbine project.
- # A prototype cold weather wind turbine will be installed at the National Wind Technology Center for certification and long-term reliability testing.
- # 2,300 MW of domestic wind generating capacity achieved.

FY 2001 - 2006 Performance Measures

- # Three new small wind turbines and one cold weather turbine will be commercially available to compete in international markets.
- # Next generation turbines will be in operation, capable of producing electricity at \$0.025/kWh at sites with 15 mph annual average windspeeds.
- # Two additional U.S. companies will provide utility-scale wind turbines, compared with one in 1999.
- # U.S. industry will capture 25% of the world market for wind energy.

Significant Accomplishments and Program Shifts

Pre-FY 1998 Accomplishments

- # Advanced airfoils developed by the Wind Program have been adopted in three commercially available U.S. wind turbines, resulting in an increase in efficiency of up to 30% compared with previously

available blade designs. Several computational codes that are key to wind turbine design are now available or improved as a result of the Program's core R&D efforts.

- # Zond Energy Systems' emergence as the leading wind turbine manufacturer in the United States followed successful collaborative efforts with Wind Program through a Turbine Research partnership formed in 1993, and a continuing partnership under the Turbine Verification Program. Zond, now the turbine manufacturing subsidiary of Enron Wind Corporation, publicly recognizes the critical technical contributions made by the Wind Program to the success of their technology.

FY 1998 Accomplishments

- # Completed field experiment at the National Wind Technology Center (NWTC) to obtain detailed aerodynamic and structural measurements on an operating wind turbine rotor.
- # Initiated two new cost-shared projects with host utilities for field verification of advanced wind turbine technologies.
- # Obtained National Wind Technology Center accreditation for performing testing in compliance with International Standards Organization (ISO) requirements.

FY 1999 Planned Accomplishments

- # Complete validation of advanced wind turbine design codes for application to extremely lightweight, flexible designs.
- # Complete installation of prototype wind turbine under Near Term Research and Testing project, and begin field testing.
- # Establish a U.S.-based wind turbine certification agent.
- # Competitively select at least five distributed power field verification projects using smaller ($\leq 100\text{kW}$) wind turbines.

FY 2000 Planned Accomplishments

- # Complete testing of the highly instrumented aerodynamics research turbine, previously tested at the NWTC, in the NASA Ames Research Center's 80 by 120 foot wind tunnel to establish steady inflow baseline performance data.
- # Complete Near Term Research and Testing project.
- # Complete first year of operation of five distributed power field verification projects using smaller ($\leq 100\text{KW}$) wind turbines.
- # Operate utility-scale wind farms in eight additional U.S. states, compared to five at the beginning of 1998.

FY 2001 - 2004 Planned Accomplishments

- # In 2001, the Small Wind Turbine and Cold Weather Turbine projects will be complete. In 2003, the Next Generation Turbine project will be complete.
- # Cooperative Research and Testing - In 2002, at least one regional wind monitoring network will be in operation.

Program Completion

Success of the Wind Program will be gauged by completion of year 2005 and 2010 goals. In 2005, if the United States has achieved a 25% share of the world wind energy market, the program will transition away from aggressive technology development activities, and into a reduced maintenance level, providing industry unique services such as certification testing, support for resolving crosscutting issues in the industry (such as power systems integration studies), and research to improve and maintain the analytical tools needed by industry for their own technology development activities. If the capacity goals of 2010 are achieved, then an evaluation will be conducted to determine the appropriate level, if any, for continued Federal support for the U.S. wind industry.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	\$ Change	% Change
Applied Research	11,101	10,700	13,500	+2,800	+26.2%
Turbine Research	13,000	16,400	20,200	+3,800	+23.2%
Cooperative Research and Testing	8,027	7,671	11,900	+4,229	+55.1%
Total, Wind Energy Systems	32,128	34,771	45,600	+10,829	+31.1%

Detailed Program Justification

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Applied Research

The core research element of Applied Research focuses on advancing the U.S. wind energy technology base through research, testing, and analysis on the complexities of wind and how it interacts with wind turbine rotors, how wind turbine structures and materials react and withstand the forces of wind over time, and how all parts of wind energy systems - blades, drivetrains, generators, power converters, control systems, and towers - can be optimized for cost effectiveness and reliability. These efforts culminate in improved computational codes for wind turbine design, and identification and verification of improved wind turbine design features. Industry has relied on the Department and its laboratories for this type of research because individual

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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industry members are under-capitalized, have had little research capability, and are focused primarily on developing products. The funding level requested is based on historical experience in planning and managing numerous core research projects, and will support core research in aerodynamics, wind characteristics and forecasting, structural dynamics, and advanced components, such as adaptive blades and direct drive variable speed generators, to provide breakthrough technologies to improve cost/performance of wind technology. Field testing will be conducted at the National Wind Technology Center to further understandings of ambient inflow, turbulence, complex terrain, and rotor dynamics, leading to improved wind turbine design tools. Activities under the core research component of Applied Research are consistent with the recommendations of the President's Committee of Advisors on Science and Technology (PCAST) report on energy research and development to support research on computational fluid dynamics, light weight adaptive structures, advanced control systems, variable speed and direct drive generators.

8,801 8,600 8,000

- # Promising research ideas and concepts generated in Applied research activities will be further developed and tested by a joint team of industry and laboratory researchers under a new activity, Wind Partnerships for Advanced Component Technologies (WindPACT). Two to three R&D subcontracts will be competitively selected to explore potential concepts such as light-weight and direct-drive generators, flexible and articulated rotors, feedback controls for load alleviation, and high efficiency power converters. WindPACT will provide the avenue needed to continue transfer of technology from the Program's core research activities to industry, beyond what will occur in the next-generation turbine efforts. The added technology advancement will contribute to entry of additional U.S. wind companies with leading-edge, highly cost-effective

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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products making a contribution to meeting the program's 2005 25% world market share goal, as well as the 2010 domestic capacity goal. The funding requested will support an appropriate level of laboratory effort to bring two to three candidate technology concepts to the stage of development needed to then initiate competitively selected multi-year industry partnerships.

0 0 3,000

The Wind Program relies on universities (including Historically Black Colleges and Universities (HBCUs) and Hispanic Educational Industries) to provide new theories and concepts for improved wind technologies. Funding requested is required to support a new competitive solicitation for advanced aerodynamic modeling codes, wind turbine controls research, and to continue materials research with Montana State University in coordination with the Office of Science (formerly the Office of Energy Research).

1,000 1,100 1,000

Applied Research also includes R&D for technologies that enable wind to be used in stand-alone, hybrid power systems. The combined use of wind turbines with diesel generators and other renewables and storage systems is a potentially major market for U.S. technology. The major research issue is design of a control system to allow the diesels to be turned off when possible to reduce overall consumption of diesel fuel. In addition to control systems R&D, the Program is supporting a control system field verification project in Alaska, with approximately 60% of project funding provided by sources other than the Department. The requested funding level is based on the anticipated laboratory in-house, consultant, and hardware costs for completing testing of a new wind hybrid power system, with an industrial partner, using the NWTC wind/hybrid test facility. The funding will also continue support of hybrid wind projects in Alaska, and evaluation of commercial control systems at the NWTC hybrid power test bed and at the USDA research facility in Bushland, Texas. .

1,000 700 1,000

(dollars in thousands)

	FY 1998	FY 1999	FY 2000
# Avian concerns can pose a significant challenge to siting and operation of wind turbines. For this reason, continued research is needed to identify mitigation measures that would reduce adverse impacts that might otherwise occur, and to provide guidance for appropriate siting of wind facilities. The requested funding level is based on requirements for supporting laboratory in-house costs, and initiation of a subcontracted control study of avian impacts at an operating wind facility.	300	300	500
Total, Applied Research.	11,101	10,700	13,500

Turbine Research

# The Next Generation Turbine project is the Wind Program's primary investment in achieving a cost of energy from wind of \$0.025/kWh by 2002. This project is focused on completing research and development with two industry partners leading to state-of-the-art utility scale (500kW - 2MW) wind turbines. Requested funding is based on projected spending for the two cost-shared industry subcontracts (30% industry share), and will support component qualification testing and final design of engineering and manufacturing development turbines.	5,000	3,100	8,000
# Conduct Near Term Research and Testing project to support U.S. industry in reducing costs, enhancing reliability, and obtaining certification for wind turbines targeted for near-term markets. The funding level requested is based on projected spending requirements for one subcontract and will support final design and field testing of a 750 kW prototype turbine, and completion of the project.	2,000	3,600	400
# Conduct Small Wind Turbine projects to assist U.S. industry in research and development of wind turbines in the 8-40 kW range for stand-alone, remote, hybrid, and home/farm power applications. The requested funding level is based on spending projections for three subcontracts, and will support completing installation and beginning field testing of three small wind turbine prototypes.	500	700	1,000

(dollars in thousands)

	FY 1998	FY 1999	FY 2000
# The Wind Program will take the lead in completing prototype development, testing, and field verification for the Cold Weather Turbine project, targeted for locations such as Alaska and the South Pole, as the third phase of a Small Business Innovation Research effort begun by the National Science Foundation and the National Aeronautics and Space Administration. The project will employ direct-drive generator technology developed under the Wind Program's Next Generation Innovative Subsystems project to be completed in FY 1999. The requested funding level is based on projected spending for one industry subcontract, and will support completing research and development for the cold weather turbine prototype, and initial testing at the National Wind Technology Center and a location in Alaska.	0	300	800
# The supporting research and testing element of Turbine Research assures that industry's wind turbine R&D efforts take full advantage of the Wind Program's technology developments, and provides resources to conduct testing and analysis otherwise unavailable to industry. Field verification of new wind turbine technologies serves a vital function in Turbine Research by continuing close technical support through industry's initial installation of turbines in actual utility operating environments. Further, field verification projects provide an avenue for accelerating the regional diversification of wind energy by supporting installation of advanced wind technologies in several new areas across the Nation.			
Funding requested for supporting research and testing is based on previous experience with the level of support needed for Turbine Research and Turbine Verification Program activities, and the industry and utility cost-sharing level of 20% to 75%. The funding will support design review, analysis and testing services needed for several new on-going Turbine Research subcontracts with industry. In addition, field verification projects will be initiated that will be tailored to satisfy specific regional needs. Technical and data analyses support will be continued for ongoing Turbine Verification Program projects as well as for smaller wind turbine field verification projects initiated in FY 1999. . . .	5,500	8,700	10,000
Total, Turbine Research.	13,000	16,400	20,200

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Cooperative Research and Testing

# Cooperative Research and Testing will provide support to the U.S. wind industry, focused through the National Wind Technology Center, in resolving near-term technical problems and providing technical support for competing in world markets. The requested funding level is based on past experience in the level of support needed to complete activities that assist the U.S. wind industry in resolving near-term technical problems and enhancing technology transfer, providing technical support for the U.S. manufacturers competing in world markets, and supporting domestic field verification projects such as the Navy wind project on San Clemente Island, and estimated cost-sharing of 50%.	3,600	1,500	3,000
# Initiate a new cooperative effort with industry, Hybrid Systems for Village Power, that will follow from the ongoing hybrid field verification projects in Alaska and provide additional opportunities for field verification of new wind hybrid power systems technologies developed under Applied Research. This project will verify and improve technologies that enable reducing fuel use and emissions at existing stand-alone diesel power systems in Alaska and other States, U.S. trust territories, Native American communities, and in many overseas remote applications. The requested funding level is based on the Wind Program's previous experience with the cost of similar field verification and hybrid systems projects. Two to three projects will be competitively selected and cost-shared by the local utility and/or village.	0	0	2,500
# Continue support for developing international consensus standards for wind turbine design, and the establishment of wind turbine certification capability in the United States. Both of these activities are essential to maximizing U.S. industry's prospects for international sales, and thus increased market share. The requested funding is based on anticipated laboratory in-house costs, consulting and equipment costs for internationally-accepted standards activities and continued certification program development and testing for the newly established U.S. based wind turbine certification agent.	2,000	3,371	2,500

Energy Supply/
Solar and Renewable Resources Technologies/
Wind Energy Systems

FY 2000 Congressional Budget

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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- # The Wind Energy Systems Program seeks to competitively fund the startup and infrastructure costs of a voluntary Wind Performance Monitoring Network in the Midwest in which the operator would become self-supporting after the initial startup. The result of this effort will be verifiable data on long term performance of these new wind projects, especially concerning ancillary service requirements, and strategies to accelerate the use of wind energy by wind developers, power marketers, renewable and other power aggregators and power system operators.

The Wind Performance Monitoring Network is vital to the overall Wind Program effort to study and understand the integration of wind energy into the electric power systems to facilitate utility sector acceptance. As a high capital cost, low fuel cost option, wind energy is currently at a disadvantage in the restructured marketplace that favors low capital, low fuel cost options such as natural gas. In addition, the rules of the emerging marketplace require that each generating project pay for its share of costs related to transferring power to point of use and providing a secure system. FERC calls these costs 'ancillary services' and requires a generator to provide or acquire them. Also, the variation of the wind resource across a region is critical to determining the value of wind energy in the new competitive marketplace. The requested funding level is based on laboratory in-house costs for on-going studies and to initiate the wind monitoring network.

1,127	1,500	2,600
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- # Continue operation of the National Wind Technology Center operations to maintain world class research and testing capabilities and facilities for the U.S. wind industry. The requested funding level is based on requirements for laboratory site support staff, contractors and equipment. . .

1,300	1,300	1,300
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Total, Cooperative Research and Testing.

8,027	7,671	11,900
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Total, Wind Energy Systems.

32,128	34,771	45,600
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Explanation of Funding Changes from FY 1999 to FY 2000

FY 2000
vs. FY 1999
(\$000)

Applied Research

- # The increase supports the Wind Partnerships for Advanced Component Technologies project which will develop 2-3 innovative concepts in the laboratory, and competitively select industry partners for further development. +2,800

Turbine Research

- # The increase supports planned higher spending on next generation turbine subcontracts in FY 2000 as these efforts enter a peak period of engineering development and hardware procurement. +3,800

Cooperative Research and Testing

- # The increase supports Hybrid Systems for Village Power project and a Wind Monitoring Network in which several new partners will be competitively selected to carry out field activities for these projects. +4,229

Total Funding Change, Wind Energy Systems	+10,829
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Renewable Energy Production Incentive

Mission Supporting Goals and Objectives

Program Mission

The mission of the Renewable Energy Production Incentive (REPI) is to encourage the acquisition of renewable energy generation systems by state and local governmental entities and non-profit electric cooperatives. For these tax-exempt owners of new renewable energy generation systems, REPI provides financial incentives that are comparable to the value of either production tax incentives or investment tax credits that are available to the private-sector owners of certain types of new renewable energy generation systems. For comparability, new renewable energy generation systems that use solar, wind, geothermal, or closed-loop biomass technologies receive priority for REPI payments over systems that use allowable open-loop biomass technologies. Each qualified facility, first operated in the fiscal year 1994-2003 time frame, is eligible for incentive payments for the net electricity produced during the first 10 fiscal years of its operation, subject to the availability of annual appropriations.

Program Goals and Objectives

A major goal in the annual budget request for REPI is to provide financial incentives for public entities that acquire new renewable energy generation facilities that are comparable to the tax incentives that are available to the private sector. In order to accomplish this goal and to maintain a balanced portfolio for the Solar and Renewable Energy account, full incentive payment funding is planned for all new qualified facilities that use solar, wind, geothermal, and closed-loop biomass technologies. A lesser level of payments is planned for new qualified facilities that use open-loop biomass technologies.

Strategic Approach

Both the Department's Strategic Plan and the Comprehensive National Energy Strategy have a goal of doubling the non-hydroelectric renewable energy generating capacity by 2010. The portfolio of renewable energy research and development programs is improving the performance and reducing the cost of these technologies. However, temporary government support, as envisioned in the report of the President's Council of Advisors on Science and Technology, is needed to facilitate the demonstration and use of these technologies. REPI provides this temporary financial support to the non-Federal public sector. This financial support is comparable to the value of tax incentives that are being provided to the private sector for the near-term acquisition and operation of solar, wind, geothermal, and closed-loop biomass generation systems.

Program Benefits

Metric	FY 2000	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.00	0.02	0.10
Energy Savings (\$ Billions)	0.00	0.05	0.25
Carbon Displaced (MMTCE)	0.09	0.33	1.43

Performance Measures

- # FY 1998 appropriations provided incentive payments for qualified facilities that generated approximately 460^a million kilowatt-hours in fiscal year 1997.
- # It is anticipated that REPI will annually facilitate the addition of new qualified facilities to the program through fiscal year 2003 with these facilities producing approximately one billion kilowatt-hours of electricity in fiscal year 2003.

Significant Accomplishments and Program Shifts

FY 1998, FY 1999, and FY 2000 appropriations will be sufficient to make production incentive payments for all of the electricity generated by qualified facilities which use solar, wind, geothermal, or closed-loop biomass technologies. Only a portion of the electricity produced by qualified facilities which used open-loop biomass technologies will receive incentive payments, determined by the availability of remaining appropriated funds.

Program Completion

The last fiscal year of electric production that is eligible for payments under this program is FY 2012. Therefore, production incentive payments using FY 2013 appropriations, if provided, will be the final planned activity for this program.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	\$ Change	% Change
Renewable Energy Production Incentive	2,954	4,000	1,500	-2,500	-62.5%
Total, Renewable Energy Production Incentive ...	2,954	4,000	1,500	-2,500	-62.5%

^aThe change from 570 to 460 is due to a recent discovery by the Golden Field Office of an error in computations by the applicant of the program's largest qualified facility.

Detailed Program Justification

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Annual Production Incentive Payments

Payments will be provided to the owners of approximately 25 qualified facilities at the rate of about \$0.017/kWh. Make full production incentive payments for all the electricity produced by qualified facilities that use solar, wind, geothermal, or closed-loop biomass technologies. This provides comparability to tax incentives provided to private sector owners of similar systems. Payments for only a small portion of the electricity, on a pro rata basis, will be made to owners of facilities that use open-loop biomass technologies.

2,954 4,000 1,500

Total, Renewable Energy Production Incentive

2,954 4,000 1,500

Explanation of Funding Changes from FY 1999 to FY 2000

FY 2000 vs. FY 1999 (\$000)

Renewable Energy Production Incentive

The decrease is due to shift of funds to higher priority R&D activities. Since comparable incentives are not provided to private sector owners of these systems, provide a lesser level of incentive payments to qualified facilities that use open-loop biomass technologies.

-2,500

Total Funding Change, Renewable Energy Production Incentive.

-2,500

Solar Program Support

Mission Supporting Goals and Objectives

This budget category consists of two components: Electricity Restructuring and Competitive Solicitation. Each is discussed individually below.

Program Mission

Electricity Restructuring - The mission of the Electricity Restructuring program is to provide unbiased technical assessments to Federal and State officials of utility restructuring issues relating to renewable energy and energy efficiency. The assessments will help decision makers at the Federal and State levels both develop and coordinate utility restructuring regulations and legislation to ensure suitable policy and market mechanisms for renewable energy and energy efficiency.

Competitive Solicitation - The mission of this program is to obtain, analyze, and disseminate essential cost and operational information necessary to overcome the perceptions of risk in selecting renewable energy and hybrid renewable energy generation/cogeneration systems for use in the competitive electric market.

Program Goals and Objectives

Electricity Restructuring - The goal of Solar Program Support is to assist State, regional, and Federal agencies in developing utility restructuring concepts for energy efficiency and renewable energy technologies and programs. A key objective is to assess the costs and benefits of renewable portfolio standards, public benefits funds, consumer information and disclosure provisions, green marketing programs, distributed generation concepts, and other policy and market mechanisms for energy efficiency and renewable energy technologies in restructured utility markets. Another objective is to provide unbiased information and materials to State, regional, and Federal decision makers on the costs and benefits on utility restructuring concepts for energy efficiency and renewable energy technologies and programs. Also, to assist in the coordination of Federal, regional, and State agencies in the implementation of utility restructuring legislation and regulation for energy efficiency and renewable energy technologies and programs following enactment of Federal legislation.

Competitive Solicitation - Through a technology-focused and competitive process, carry out targeted field validation efforts that simultaneously: 1) prove the availability of clean, affordable, and reliable electric power supply options for many remote and/or economically challenged regions of the Nation; and 2) obtain essential data on operational performance, reliability, and benefits of renewable energy and hybrid renewable energy generation/cogeneration systems in various geographic locations and climatic conditions.

The objectives from this effort will be to make information resulting from these validation efforts available, in easy-to-understand format, to decision makers considering additional or replacement power generation systems; and substantially contribute to the achievement of tripling renewable energy

generation capacity (non-hydroelectric) in the U.S. by 2010, consistent with both the Department's Strategic Plan and the Comprehensive National Energy Strategy.

Strategic Approach

Electricity Restructuring - The Electricity Restructuring Program seeks to inform state energy and environmental policy officials about the potential effects of utility restructuring policies and regulations on the development and deployment of renewable and energy efficiency technologies and programs. This is accomplished through technical analysis and assistance to key state officials on policy and market based mechanisms for supporting renewable and energy efficiency technologies in competitive utility markets.

The program accomplishes this mission by sponsoring technical analysis and outreach to disseminate findings quickly and cost effectively. The program establishes partnerships with State, regional, and national organizations that have roles in utility restructuring legislation and regulation.

The program is critical to the future of energy efficiency and renewable energy technologies in restructured electricity markets. Federal electricity restructuring legislation is pending. Some States have implemented electricity restructuring legislation and/or regulations, others have not. There is no national effort, other than this program, aimed at achieving better Federal-State coordination on electricity restructuring and energy efficiency and renewable energy technologies and programs.

Competitive Solicitation - Competition resulting from the restructuring of the electric utility industry will favor the selection of systems with low first costs over systems with higher first costs, but comparable or lower life-cycle costs. From a risk perspective, energy providers will also select advanced generation technologies that have evolved from familiar fossil-fuel technologies, which have had long service lives and high levels of reliability and scheduled availability. Emerging generation technologies, such as renewable energy, are at a market selection disadvantage due to the lack of comparable cost and operational information. This multi-year program is directed at obtaining vital cost and operational information for a wide variety of systems in various sectors (including Federal facilities and Native American localities) and various geographic regions. By 2004, the program will have completed planned funding of cost-shared field verification projects for renewable energy and hybrid renewable energy generation/cogeneration systems.^a

The portfolio of renewable energy research and development programs is improving the performance and reducing the cost of these technologies. However, reports such as that by the President's Council of Advisors on Science and Technology indicate that R&D alone is not sufficient to launch new technologies in the market. Among the substantial market barriers discussed in this report are the perceptions of risk with new emerging technologies, such as renewable energy generation. To address these perceptions of risk, this program funds a spectrum of cost-shared field verification projects in various geographic regions to obtain the needed cost and operational information for these renewable energy systems.

^aHybrid systems could include combinations of renewable energy generation technologies, integrated renewable energy/energy storage systems, and integrated systems utilizing renewable energy and fossil fuels (such as natural gas or coal).

The Competitive Solicitation program is designed to combine the various activities previously conducted under two separate line items (the Renewable Indian Energy Resources and Federal Buildings/Remote Power programs) into a single, integrated effort that provides highly cost-shared competitive awards to projects selected across a diverse range of geographic locations. A deliverable requirement is 3 years of operational information on field verification projects, including the amount of electric generation and system outage information, if any.

The program is composed of three competitive components: systems benefitting Native Americans, systems benefitting Federal facilities, and systems that would be selected in an open portion of the solicitation. Cost-sharing requirements for all work would be in the ratio of 3 non-DOE dollars to each DOE dollar of funding for systems benefitting Federal facilities and systems selected under the open portion.

For systems benefitting Native Americans, the cost-sharing of 25 percent or greater per DOE dollar of funding would be encouraged. Where feasibility studies are funded, the same cost-sharing goals apply. For systems benefitting Federal facilities, the provisions of Executive Order 12902, "Energy Efficiency and Water Conservation at Federal Facilities" will be applied. Since this Executive Order requires comprehensive facility audits, the funding of feasibility studies will not be required to ensure a viable pool of field verification projects. These projects will be competitively selected under a process managed by the Department's Federal Energy Management Program. The other two categories (systems benefitting Native Americans and systems selected under the open portion) will be administered through a competitive financial assistance process. In order to ensure a viable pool of field verification projects over the time frame of this program, a portion of the funding for these categories in FY 2000 will be used for cost-shared feasibility studies. These studies will address the economics, needed licenses and permits, and potential environmental issues for the proposed field verification project.

Assuming level funding over the six-year life of the Competitive Solicitation program, up to 200 field verification projects utilizing renewable energy will be installed in various locations across the Nation (the actual number of projects depends upon the size and cost of projects selected from the annual competitions).

Program Benefits

Metrics	FY 2000	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.00	0.00	0.00
Energy Savings (\$ Billions)	0.00	0.00	0.00
Carbon Displaced (MMTCE)	0.01	0.06	0.06

Although the primary purpose of this program is field verification of various power generation systems that utilize renewable energy technologies, the impact upon the lives of those receiving the electricity from these systems is not insignificant. In fact, once all the projects are completed these systems will produce the amount of electricity needed to power more than 22,500 homes across the Nation.

Performance Measures

FY 2000 Performance Measures

Electricity Restructuring

- # Increased consistency between State and proposed Federal legislation in the key parameters for renewable portfolio standards, public benefits funds, net metering programs, and consumer information and disclosure provisions.
- # Increased number of publications, technical analyses, and presentations for State officials on electricity restructuring issues.
- # Increased level of understanding by State officials on electricity restructuring issues as demonstrated by State policy decisions to support public benefit mechanisms.
- # Development of at least two regional market strategies, indexes, for energy efficiency technology deployment and effectiveness measurement techniques for use by States in their restructuring legislation and regulations.

Competitive Solicitation

- # Not applicable - new program in FY 2000. See Planned Accomplishments for projected FY 2000 achievements for this program.

FY 2001 - 2006 Performance Measures

Electricity Restructuring

- # Increased number of information publications, materials, industry web site access, conference presentation over FY 2000.
- # Development of two additional regional market strategies for energy efficiency technology deployment.
- # Legislation enacted by all States consistent with proposed Federal electricity restructuring legislation requirements for public benefits.

Competitive Solicitation

- # The six year program will result in at least 100 cost-shared field verifications of renewable energy and renewable energy hybrid generation/cogeneration systems of various system configurations for various geographic regions.
- # The direct savings of the systems should be approximately \$4,500,000 annually in energy costs. Indirect savings will be substantially higher; the cost and operational information from these systems will address the market perceptions of risk in the selection of these systems and thereby facilitate the selection of similar systems.

Significant Accomplishments and Program Shifts

Pre-FY 1998 Accomplishments

Electricity Restructuring

No program funds available.

Competitive Solicitation

No program.

FY 1998 Accomplishments

Electricity Restructuring

No program funds available.

Competitive Solicitation

No program.

FY 1999 Planned Accomplishments

Electricity Restructuring

Funding for this program was appropriated through Solar Program Direction.

Reports on the impacts and implementation policies of State restructuring legislation and regulations on renewable and energy efficiency technologies.

Two regional workshops on electricity restructuring issues.

Technical assistance on electricity restructuring issues provided to States, individually.

Technical assistance to State organizations on electricity restructuring issues.

Competitive Solicitation

No program.

FY 2000 Planned Accomplishments

Electricity Restructuring

Reports on the impacts and implementation policies of State restructuring legislation and regulations on renewable and energy efficiency technologies.

Two regional workshops on electricity restructuring issues.

Technical assistance on electricity restructuring issues provided to States, individually.

Technical assistance to State organizations on electricity restructuring issues.

Competitive Solicitation

- # Competitively aware approximately 1-25 field validation projects and initiate development of same. Selected projects will reflect a range of technology applications and a diversity of geographic locations and climate conditions.

FY 2001 - 2004 Planned Accomplishments

Electricity Restructuring

- # Reports on the impacts and implementation policies of State restructuring legislation and regulations on renewable and energy efficiency technologies.
- # Two regional workshops on electricity restructuring issues.
- # Technical assistance on electricity restructuring issues provided to States, individually.
- # Technical assistance to State organizations on electricity restructuring issues.

Competitive Solicitation

- # A sufficient range of 100-200 highly leverages (a minimum of 50% cost-share is required except in the Native American component which requires 25%), competitively-awarded projects would be funded under this program. Projects would be selected based upon criteria ensuring technology and configuration variety, high value of data to be received, and geographic/climate diversity. Such a diverse array of projects operating under a range of conditions is essential in order to reduce the perceptions of risk surrounding the development of power generation facilities that utilize renewable energy technologies, and to obtain the hard performance data required by potential decision makers, investors and financial institutions.

Program Completion

Electricity Restructuring

The Electricity Restructuring program will be completed by FY 2005, as all States implement their individual and Federal restructuring requirements.

Competitive Solicitation

Assuming level funding over the planned six-year lifetime of this program, final cost-shared field verification project awards will be made by FY 2005. Projects initiated in FY 2005 should be completed by the end of FY 2006. Data on operational performance, system reliability, and other essential project information is required from each project once its operation begins so that this information can be consolidated and shared with decision makers considering the use of renewable or hybrid renewable power when they are faced with adding new or replacing existing power supplies. The comparatively small, but vital, project information collection component of this effort is projected to continue until approximately FY 2009 - FY 2010, at which time the entire program will conclude.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	\$ Change	% Change
Electricity Restructuring					
Technical Analysis & Technical Assistance	0	0	2,000	+2,000	>999.9%
Subtotal, Electricity Restructuring	0	0	2,000	+2,000	>999.9%
Competitive Solicitation					
Feasibility Studies	0	0	1,000	+1,000	>999.9%
Field Verification Projects	0	0	7,000	+7,000	>999.9%
Subtotal, Competitive Solicitation	0	0	8,000	+8,000	>999.9%
Total, Solar Program Support	0	0	10,000	+10,000	>999.9%

Detailed Program Justification

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Electricity Restructuring

Technical Analysis and Assistance - Electricity restructuring information and analyses will be disseminated to State and regional electricity agencies, power supplies, energy service companies, and other market participants on energy efficiency and renewable energy technologies in competitive electric markets. The information will focus on what has worked in one region or state to assist other states in development of their policies or restructuring. Publications, presentations, web site development will be used to disseminate these “lessons learned.” Substantive expertise in utility regulations, energy technologies, and power systems is required to provide accurate, unbiased analyses of the changing competitive marketplace.

Specific analytic activities include analysis of policy mechanisms such as information disclosure provisions, renewable portfolio standards and public benefits funds. Analysis of future utility and regulatory systems such as distributed power, bid-based pools, and real-time pricing will be performed. Analysis of market mechanisms such as labeling of electricity products for consumers, “green” certification, and energy services strategies will also be completed. Technical assistance will be provided to support regional State, and Federal decision makers in the

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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electricity restructuring process. Funds will be provided if selected in a competitive solicitation process, to key electric utility governmental associations, such as the National Association of State Legislatures, National Association of State Energy Offices, and others. The funds will support regional networks, seminars, workshops, information dissemination mechanisms such as web sites, in order to inform decision makers on electric restructuring and the role of energy efficiency and renewable energy technologies. These activities will ensure that State have the most recent, accurate, and unbiased information available on electric restructuring and the impacts on renewable and energy efficiency technologies.

The funding level for the technical analysis and assistance activities is appropriate given the expected number of States (30) that will be implementing electricity restructuring activities in FY 2000. The level of funds is also based on experience with competitive selection of State organizations for technical assistance as appropriate to meet the informational and technical analytic needs of State decision makers.

0	0	2,000
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Competitive Solicitation

Conduct cost-shared feasibility studies required to ensure a viable pool of field verification projects. These funds will enable the competitive selection of cost-shared feasibility studies which will provide a pool of viable field verification projects in the remaining years of the program. Any unnecessary amount of this requested portion of the Competitive Solicitation would be applied to field verification project completion.

0	0	1,000
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Cost-shared field verification projects to obtain needed cost and operational information. A sufficient range of 100-200 highly leveraged (a minimum 50% cost-share is required except for the Native American component which is 25%), competitively-awarded projects would be funded over the lifetime of this program. Projects (approximately 15-25)

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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would be selected based upon criteria ensuring technology and configuration variety, high value of data to be derived, and geographic/climate diversity. Such a diverse array of projects operating under a range of conditions is essential in order to obtain the hard performance data required by potential decision makers, investors and financial institutions and to reduce the perceptions of risk surrounding the development of power generation facilities that utilize renewable energy technologies. The funding levels requested below were established through experience-based estimates of the range of possible projects and required cost-share levels, are consistent with program goals and objectives, are equivalent to the combined funding levels of the former Renewable Indian Energy Resources Program and the Federal Buildings/Remote Power Program from which this consolidated program is derived, and are sufficient to meet anticipated FY 2000 needs.

Total, Competitive Solicitation.	0	0	7,000
Total, Solar Program Support.	0	0	10,000

Explanation of Funding Changes from FY 1999 to FY 2000

FY 2000 vs. FY 1999 (\$000)

Electricity Restructuring

\$1,900,000 for Electricity Restructuring, previously funded under Program Direction, is increased \$100,000 under Solar Program Support. These funds will provide increased technical analysis on electric restructuring impacts on renewable and energy efficient technologies which will be disseminated to State decision makers. +2,000

Competitive Solicitation

The \$8,000,000 will initiate this activity to include \$1,000,000 for feasibility studies to support competitive selection of cost-shared feasibility studies to ensure a pool of viable field verification projects, and \$7,000,000 for the initial round of projects. . . +8,000

Total, Funding Change, Solar Program Support. +10,000

International Solar Energy Program

Mission Supporting Goals and Objectives

Program Mission

The Solar International Program's mission is to encourage the acceptance and use of U.S. renewable energy technologies by developed transition and developing countries in support of U.S. national interests and policies. The Solar International Program, achieves its mission by advancing technology development and deployment based on selection and implementation of priority activities, working cooperatively with the private sector, federal agencies, and others.

Program Goals and Objectives

EERE activities carried out jointly with other countries contribute directly to fulfilling critical Department of Energy missions — achieving efficiency in energy use, diversity of energy supply, a more productive and competitive economy, improved environmental quality, and enhanced energy security.

Widespread use of U.S. energy efficiency and renewable energy technologies can help meet the energy needs of developed, transition and developing countries; reduce the rate of consumption of finite global resources; and address local and transnational environmental issues. More efficient use of fossil fuels and increased use of renewable energy improves U.S. energy security. By shifting consumption away from traditional, but non-sustainable energy resources, the local environmental impacts of fossil fuel production and consumption can be mitigated, while concurrently reducing regional instability by reducing competition for scarce resources.

Expanding U.S. exports will help U.S. industries achieve manufacturing economies of scale. This will contribute to the cost competitiveness of U.S. energy efficiency and renewable energy technologies both domestically and internationally by lowering their unit costs. In addition, increased sales of U.S. energy efficiency and renewable energy technologies create jobs in the high-technology sector, where U.S. labor enjoys a comparative advantage and salaries are markedly higher than in other sectors. These efforts, and others, help U.S. industry gain a foothold in the fastest growing, and often most difficult-to-penetrate, international markets for energy products and services. Such sales by U.S. industry also generate the revenue needed to support continued domestic research and development toward improving technology and product performance. Without increasing research and development expenditures, other nations will continue to erode the U.S. technological advantage built during the 1980's.

Facilitating international technology cooperation advances U.S. interests in global energy and environmental objectives in bilateral and multilateral discussions, agreements and treaty negotiations. Developing and facilitating the deployment of appropriate technologies offers U.S. industries the opportunity to adapt existing or emerging technologies to meet unique needs and conditions of developing and transition countries. Technologies that may face significant commercial barriers domestically may be readily adaptable to large and growing markets in the developing world.

Given the large number of requests for international initiatives and activities, the Office of Energy Efficiency and Renewable Energy will use a set of evaluation criteria to assist with selection of priority

activities. These criteria will consider whether the proposed activity advances U.S. strategic interests and policies; the DOE mission; opportunities for leveraging U.S. funds; national, regional or global impacts; potential for replication; contribution to technology development; commitments by other partners; likely impact on U.S. market competitiveness; and other relevant factors. EERE international activities will be screened, ranked, and implemented appropriately.

Strategic Approach

The International Solar Energy Program and U.S. Initiative on Joint Implementation will be refocused in FY 2000 using the three specific elements of Emerging Global Environmental and Energy Issues, Market and Trade Development, and Energy and Environmental Security.

While the use of essentially all renewable energy and energy efficiency technologies can help mitigate global climate change and other associated environmental and health threats, the Emerging Global Environmental and Energy Issues element will be implemented specifically through and in conjunction with the U.S. Initiative on Joint Implementation (USIJI). USIJI is a DOE-lead interagency program that supports the development of flexibility mechanisms under the U.N. Framework Convention on Climate Change (FCCC) such as Joint Implementation (JI), Clean Development Mechanism (CDM), and Emissions Trading. Meaningful participation by developing countries in the proposed 1997 Kyoto Protocol to the U.N. FCCC will also be accelerated.

The Market and Trade Development element will accelerate reductions in technology production costs and advance deployment of technologies through overseas market expansion. It will stimulate global economic development and regional economic stability, and accelerate domestic economic growth and employment. This element will be implemented in key regions through bilateral (e.g., Gore-Mbeki) and multilateral (e.g., Asia Pacific Economic Cooperation, Hemispheric Initiatives and International Energy Agency) technology cooperation activities and information dissemination. The program will facilitate private sector technology development and deployment in strategic and emerging markets will be stimulated through project based activities.

The Energy and Environmental Security element is designed to advance U.S. strategic interests in bilateral and multilateral energy and environmental security activities and will provide specialized assistance in the utilization of appropriate technologies. This element will be implemented in support of existing and emerging bilateral and multilateral treaties and agreements (e.g., U.S.-China Energy Efficiency and Renewable Energy Protocol). In addition to these planned activities the program will help meet U.S. obligations and commitments to provide disaster relief and assistance by facilitating greater use of energy efficiency and renewable technologies that are appropriate for local conditions. These activities will be consistent with applicable legislative and budgetary authorities.

Program Benefits

Metrics

By FY 2005, the Solar International Program will stimulate \$10.00-\$20.00 in exports for every dollar spent.

The International Solar Energy Program will yield benefits in terms of the environmental and energy savings in the countries purchasing the technologies, while increasing U.S. exports, jobs, and Federal tax revenues.

Performance Measures

FY 2000 Performance Measures

- # Provide technical assistance to U.S. companies and key developing and transition countries interested in participating in Joint Implementation, and the other flexible market based mechanisms under the U.N. Framework Convention on Climate Change. Co-sponsor two project development activities.
- # Accept 5-10 projects that satisfy the interagency U. S. Initiative on Joint Implementation program's established criteria.
- # Provide technical assistance support to the implementation and evaluation of five technology deployment projects initiated by the private sector or other parties in selected key countries.
- # Educate other agencies involved in disaster relief in the opportunities for using energy efficiency and renewable energy technologies to meet humanitarian and economic redevelopment needs of disaster stricken communities.
- # Provide technical assistance to one-to-two disaster relief efforts which demonstrate the benefits of energy efficiency and renewable energy technologies.

FY 2001 - 2006 FY 2000 Performance Measures

- # Co-sponsor six project development activities in key regions and in key developing and transition countries to build greater capacity in other nations and their local organizations to facilitate meaningful participation in Joint Implementation, and the Clean Development Mechanism under the U.N. Framework Convention on Climate Change (FCCC). These activities would also include technology cooperation efforts that facilitate local acceptance and use of U.S. technologies, and meet U.S. commitments to promote clean energy technologies under the U.N. FCCC.
- # Sponsor three project development events in the U.S. for developing private sector interest in Joint Implementation, Clean Development Mechanism and Technology Cooperation.
- # Accept 5-10 projects that meet the criteria established by the interagency U.S. Initiative on Joint Implementation (USIJI). Build greater capacity for U.S. companies and other project developers to effectively prepare project proposals with sufficient information to satisfy the established USIJI program criteria.
- # Facilitate implementation of 10-20 private or multi-lateral technology projects as a result previous year's efforts to verify the effectiveness of energy efficiency and renewable energy technologies deployed.
- # U.S. agencies involved in world wide disaster relief successfully incorporate energy efficiency and renewable energy technologies into their standard practices.

Significant Accomplishments and Program Shifts

Pre-1998 Accomplishments

- # The International Solar Energy Program identified 175 project opportunities for the renewable industry, valued at approximately \$1.5 billion, and helped 16 projects secure outside funding totaling \$200 million.
- # The International Solar Energy Program assisted private industry primarily by providing technical and project assistance in instituting greenhouse gas emission mitigation projects in other countries to increase exports of U.S. technologies. Seven projects have been identified representing \$40 million in private investment and built technical capacity, both domestically and internationally.

FY 1998 Accomplishments

- # Accepted eight projects into the International Solar Energy Program which have established a baseline scenario representing 17.6 million metric tons of CO₂ sequestered/displaced over the project life at an aggregate investment of \$23.3 million by investor organizations.
- # Co-sponsored five technical assistance and training activities in Canada, Japan, China, Malaysia, and South Africa.
- # Ten projects implemented with technical assistance provided by the International Solar Energy Program.
- # Provided technical assistance to four countries interested in participating in the U.N. Framework Convention on Climate Change and implementing a Joint Implementation Program.
- # Provided technical assistance to 10 project developers in the areas of methodological development and implementation, assistance with obtaining financing, and in-country activities.
- # Other efforts within the International Solar Energy Program were not funded in FY 1998.

FY 1999 Planned Accomplishments

- # Accept 10 projects into the Joint Implementation Program which have established a baseline scenario representing 20 million metric tons of CO₂ sequestered/displaced over the project life at a cost of \$25 million.
- # Co-sponsor three Joint Implementation/Clean Development Mechanism activities in Asia, Africa, and Latin America. These activities would include a variety of project development, technical assistance, and local training and institutional capacity building.
- # Provide technical assistance to five countries interested in participating in the U.N. Framework Convention on Climate Change and implementing a Joint Implementation Program.
- # Provide technical assistance to five project developers in areas of methodological development and implementation, assistance in obtaining financing, and in-country activities.
- # Stimulate demonstration projects through market and trade development activities, including field validation, in Asia/Pacific, Latin America, Africa, and transition countries.

- # Advance Energy and Environmental Security interests in up to 10 bilateral and multilateral negotiations or agreements.

FY 2000 Planned Accomplishments

- # Provide technical assistance to developing countries interested in establishing Joint Implementation Offices or developing joint implementation projects.
- # Provide technical assistance to U.S. companies and developing country participants in preparing projects for consideration as joint implementation projects.
- # Undertake Market and Trade Development activities to reduce non-technical barriers (e.g, financing, resources, tariffs, and local prohibitions).
- # Assist other agencies involved in disaster relief efforts in utilizing energy efficiency and renewable energy technologies to meet humanitarian and economic redevelopment needs of disaster stricken communities.
- # Provide technical assistance to one-to-two disaster relief efforts which demonstrate the benefits of energy efficiency and renewable energy technologies in different settings.

FY 2001 - 2006 Planned Accomplishments

- # Provide technical assistance to developing countries, U.S. companies, and others in estimating the climate impacts of joint implementation projects.
- # Participate in international pilot projects testing carbon credit trading programs and the evaluation of the results.
- # Participate with international organizations in drafting monitoring and verification protocols for measuring the actual carbon benefits from joint implementation projects.
- # Adapt trade development activities to be appropriate for local cultural conditions in various regions with specific market needs.
- # Implement effective agreements among U.S. agencies that provide rapid response to worldwide disaster relief utilizing energy efficiency and renewable energy technologies.

Program Completion

Completion of the Joint Implementation Program is anticipated when the instruments of the Kyoto Protocol have been established and accepted by the international community.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	\$ Change	% Change
USIJI.	1,375	6,350	6,000	-350	-5.5%
Total, International Solar Energy Program ..	1,375	6,350 ^a	6,000	-350	-5.5%

Detailed Program Justification

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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USIJI

The FY 2000 request represents the refocused activities of the International Solar Energy Program and U.S. International Joint Implementation supporting Congressional direction to continue U.S. participation in Climate Change activities conditioned upon “meaningful participation” by developing countries. Support development and implementation of the U.N. Framework Convention on Climate Change’s flexibility mechanisms to facilitate private sector project development in developing countries utilizing renewable energy, energy efficiency, and other “clean energy technologies.” Technology cooperation activities also facilitate private sector deployment of these technologies. Conduct activities in support of national action plans in selected key countries for capacity building. Initiate process for developing methodologies needed for joint implementation projects and Clean Development Mechanism and emissions trading.

^aThe FY 1999 EWD appropriation was \$1,375,000. An additional \$2,600,000 provided as part of the FY 1999 Omnibus Consolidated Appropriation Act funding package will be allocated across the three program focus areas: Emerging Global Environmental and Energy Issues; Market and Trade Development; and Energy and Environmental Security. The total for the International Solar Energy Program is \$6,350,000.

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Focus on developing highly leveraged renewable energy field validation projects in order to educate regional energy decision makers on the benefits of U.S. technologies with a view toward replication using private sector and multi-lateral financing. Provide technical assistance to ongoing and prospective field validation projects in various regions to enhance lessons learned and probability of successful replication. Support technical and information dissemination assistance to multi-agency effort to mitigate effects of regional disasters worldwide

1,375 6,350 6,000

Total, International Solar Energy Program

1,375 6,350 6,000

Explanation of Funding Changes from FY 1999 to FY 2000

FY 2000 vs. FY 1999 (\$000)

USIJI

The FY 2000 request for the International Solar Energy Program is greater than the amount provided by FY 1998 and FY 1999 EWD Appropriation. Although the FY 2000 request is slightly less than the amount provided from both the FY 1999 EWD appropriation and the Omnibus Consolidated Appropriation Act it will provide the amount of U.S. efficient and renewable technology deployment that the program would be able to facilitate as well as increase its ability to support U.S. national interests and policies.

-350

Total Funding Change, International Solar Energy Program.

-350

National Renewable Energy Laboratory

Mission Supporting Goals and Objectives

Facility operations provide for the general purpose equipment purchases and for maintaining, upgrading, and constructing National Renewable Energy Laboratory facilities and infrastructure to assure continuity of research and integrity of effort in the conduct of research and development projects for Solar and Renewable Energy activities.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	\$ Change	% Change
Facility Maintenance	1,000	3,900	1,100	-2,800	-71.8%
Construction	2,200	0	0	0	0.0%
Total, National Renewable Energy Laboratory.	3,200	3,900	1,100	-2,800	-71.8%

Detailed Program Justification

(dollars in thousands)

FY 1998	FY 1999	FY 2000
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Facility Maintenance

General Plant Projects (GPP) Funding

- ▶ NREL Infrastructure - Infrastructure renovations and upgrades at the NREL South Table Mountain (STM), and National Wind Technology Center (NWTCC) sites. Work includes minor site modifications, patching, repair, and retopping of deteriorating roads and parking lots, safety fencing, landscaping, building metering, repair and replacement of leaking roofs, and the installation of a 2,000 square foot multi-user prefabricated facility for solar radiation research to replace dysfunctional shipping and storage containers currently being used.
- | | | | |
|--|-------|-------|-----|
| | 1,000 | 1,869 | 750 |
|--|-------|-------|-----|

General Purpose Equipment (GPE) Funding

- ▶ Data Systems, NREL General - GPE activities to support the GPP project of the installation of data system infrastructure upgrades. Work includes the procurement and installation of critical Y2K compliance items such as upgraded telecommunications equipment and conversion of existing Novell software and hardware network to

(dollars in thousands)

	FY 1998	FY 1999	FY 2000
Microsoft Windows NT, upgrading the computer network backbone and the Wide Area Network, purchasing uninterruptable power supplies, and a Data Warehouse server.	0	2,031	0
▶ Provides for a variety of critical multi-program laboratory equipment to either upgrade the current capabilities at NREL or to replace equipment which has reached its serviceable life-span such as laboratory standards and calibration equipment, replacement of toxic gas monitors in laboratories, and liquid chromatograph-mass spectrometer.	0	0	350
Total Facility Maintenance.	1,000	3,900	1,100

Construction

# Field Test Laboratory Building (FTLB) Expansion, Phase III - This is the third phase of modifications to the Field Test Laboratory Building. This last phase provides for the design and construction of a 13,000 square foot conversion of existing space into research laboratories and outfitting new space for research support and includes exhaust ventilation, mechanical, and electrical utilities. The laboratories would support research related to the conversion of renewable energy resources to higher value fuels and chemicals.	2,200	0	0
Total, National Renewable Energy Laboratory.	3,200	3,900	1,100

Explanation of Funding Changes from FY 1999 to FY 2000

FY 2000 vs. FY 1999 (\$000)

Facility Maintenance

# Facility maintenance is reduced \$1,119,000 in GPP activities and \$1,681,000 in GPE. The reduction of \$1,119,000 in GPP is due to critical core infrastructure renovations and upgrades in FY 1999 (\$1,869,000) and emphasis on a prefabricated 2000 square foot research facility in FY 2000 (\$750,000). Facility maintenance is reduced \$1,681,000 in GPE due to FY 1999 funding for the Data Systems Project (\$2,031,000) and FY 2000 funding for basic laboratory equipment (\$350,000).	-2,800
Total Funding Change, National Renewable Energy Laboratory.	<u>-2,800</u>